SCIENCE INFORMATION NOTES

A collection of articles on scientific and technological topics, research policies, science and society, higher learning, etc.

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I N D I A N N A T I O N A L S C I E N C E A C A D E M Y

SCIENCE INFORMATION NOTES
(January, 1985)

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Nuclear India : A Panorama of Development

Work on the peaceful use of nuclear energy was started in India four decades ago when it was almost a frontier science and only a few developed countries were engaged on it. India's nuclear fuel cycle strategy was chalked out in 1954, namely, a first stage of natural uranium reactors for producing power and plutonium, a second stage of plutonium fast breeder reactors producing power and more plutonium and also uranium-233 from thorium, and a third stage of uranium-233 - thorium breeder reactors.

Today India is amongst a handful of nations and the only developing country to have the expertise for complete fuel cycle right from uranium exploration, mining, extraction and conversion through fuel fabrication, heavy water production and reactors to reprocessing and waste management.

Fuel

India has limited uranium resources, but its thorium resources are the largest in the world. Without depending on foreign help, India's endeavour to develop the uranium exploration, mining and extraction techniques on its own have brought her to a position where not only can it meet its own needs but can offer assistance to other developing countries.

India is one of the very few countries that have the capability of producing nuclear fuel elements for research and power reactors. About 23 years ago, India had developed and built a fuel fabrication plant at Trombay with indigenous technology. This plant not only produces natural uranium fuel elements for India's research reactors but also thorium fuel for the Fast Breeder Test Reactor and other research purposes.

Starting in 1971, Nuclear Fuel Complex at Hyderabad now manufactures complete fuel elements including zircaloy structural materials for power reactors of the pressurised heavy water type. It also fabricates fuel elements from imported enriched fuel. It produces high purity materials required by the electronics industry, seamless stainless steel tubes and seamless ball bearings.

Fabrication of plutonium fuel is an extremely difficult task because of its toxicity. But this has been successfully accomplished at the plutonium metallurgy laboratory at Trombay. The fabrication of fuel elements for the Fast Breeder Test Reactor will be undertaken in this facility.

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Heavy Water

India's nuclear power generation programme rests on pressurised heavy water reactors. There are three Heavy Water Plants in operation at Nangal, Tuticorin and Baroda, two under commissioning at Talcher and Kota, and two under construction at Thal-Vaishet, near Bombay; and Manuguru near Hyderabad.

Technology developed in the country has resulted in the successful establishment of heavy water upgrading facilities. Upgrading plants based on electrolysis and vacuum distillation designed and developed by Indian efforts, have been set up at the Kota and Kalpakkam atomic power stations.

Power Reactors

India is also one of those few countries in the world which possess valuable experience in the construction and operation of reactors. Five power reactors have been built in the country and five more are under various stages of construction.

To bring nuclear power to the country without delay and to give an opportunity to Indian technical personnel to acquire experience in operating nuclear power stations under Indian grid conditions, two units of 200 MWe each were obtained from USA and put to commercial production at Tarapur (Maharashtra) in 1969. This station uses imported enriched uranium. Since 1975, the fuel elements for the plant are being made in India using the imported enriched uranium.

The country's second power plant at Kota (Rajasthan) is a two unit 220 MWe each) system. It uses natural uranium as fuel and heavy water as moderator and coolant. The first unit of the station, though built with Canadian collaboration, started the process of indigenisation and this effort had to be considerably strengthened for the second unit which has 75% indigenous content in terms of costs. Some of the nuclear equipment manufactured indigenously include, reactor vessel Calandria and end shields, steam generators, fuelling machines, etc. This effort has culminated with the third atomic power station at Kalpakkam (Tamil Nadu) where the indigenous content has increased to 90 per cent in terms of costs. This station consists of two heavy water reactors units of 235 MWe each. The first unit has been commissioned in July 1983 recently. With this India has become the seventh country in the world that have the capability to design, build, commission and operate a nuclear power plant by indigenous efforts.

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The fourth and fifth atomic power projects at Narora (U.P.) and Kakrapar (Gujarat) will have two heavy water reactors with 235 MWe (each) capacity. These four units are of wholly indigenous design and manufacture. The indigenous technological capabilities form the base of India's future nuclear power programme which aims to generate 10,000 MW of power by 2,000 A.D., contributing about 10 per cent of the total power generation capacity of the country.

Reprocessing

About two decades ago, India became the fifth country in the world to start reprocessing of spent fuel. The reprocessing plant at Trombay was built in record time and costing less than half the cost of similar plant under construction in another country. The plant was refurbished and recommissioned successfully incorporating additions and alterations for expansion of its capacity.

A 100-tonne per year Power Reactor Fuel Reprocessing Plant has been set up at Tarapur for reprocessing the spent fuel elements from Tarapur and Rajasthan Atomic Power Stations.

Waste Management

Backed up by more than 20 years of experience in R & D, different waste management schemes for the different types of plants in the nuclear fuel cycle from mining to reprocessing have been designed, installed and are being operated. India has also developed waste immobilisation by vitrification. This experience establishes that it is possible to construct 100-200 T/yr capacity plants economically with costs much lower than the ones elsewhere in the world.

Bhabha Atomic Research Centre

Amongst the developing countries, India has the unique distinction of evolving and building nuclear science and technology right from the laboratory stage to the industrial stage largely by own efforts. The Bhabha Atomic Research Centre (BARC) is the leading institute engaged in research in basic and applied nuclear sciences. It has the major responsibility for building up an infrastructure of nuclear technology besides continuing basic research in a wide range of disciplines. Much of the R & D activities at BARC are directed to supporting the nuclear fuel cycle connected with the heavy water reactor based nuclear power programme. These include nuclear physics, reactor chemistry, nuclear materials, health and safety, radiation protection and reactor engineering.

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India has built four research reactors and a fifth one is under construction. In the field of research reactors, India's expertise is fully mature. The 1 MW swimming pool research reactor Apsara built in 1954, is still operating. A zero energy fast reactor Purnima, initially used plutonium oxide fuel elements, is being modified to run on uranium-233 as fuel. R-5 has been designed and is being built entirely by Indian experts. It incorporates many novel features including a new fuel concept.

BARC also produces a variety of radioisotopes in its research reactors for use especially in medicine, industry, agriculture and research. It has been supplying radioisotopes not only to users within the country but abroad also.

In medicine, isotopes have been used for diagnostic and therapuetic applications at various nuclear medicine centres. Radiation sterilisation facility has been set up and made available to medical products, hospitals and pharmaceutical industry. Industrial applications of isotopes have included movement of silt on the sea bed, detection of leaks in buried pipelines, seepage in dams, smoke alarms, level gauges, thickness in steel plates etc. In agriculture, applications include development of a large number of mutants in cereals and pulses. Mutants of groundnut having higher oil content, higher pod size and higher yield have been obtained and released to farmers for utilisation. Techniques for radiation disinfestation of stored wheat, inhibition of sprouting in onion and potatoes have been demonstrated successfully.

BARC provides a country-wide radiation monitoring film badge service. Surveillance of health hazards, including environment, are routinely carried out at and around all nuclear plants to assess the radioactive releases.

Experience gained in the design and fabrication of control systems and instruments for research reactors has led to the setting up of a separate electronics manufacturing unit as a Public Sector Unit known as Electronics Corporation of India Ltd.

A seismic station at Gauribidanur has been operating round the clock to detect seismic signals from nuclear explosions. An on-line computer immediately analyses the signals and prints out the relevant information.

A Variable Energy Cyclotron has been set up at Calcutta as a national research facility. It is being used by various users including several universities. Major precision parts were indigenously manufactured - some of them for the first time in the country. Work is underway to develop magnetohydrodynamic (MHD) technique for generation of power from thermal plasma. A 5 MW thermal experimental coal based MHD facility has been set up at Tiruchi (Tamil Nadu).

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Reactor Research Centre

As India's uranium resources are somewhat limited, its second stage reactors will be plutonium fuelled fast breeders. A separate research centre where a 40 MW thermal Fast Breeder Test Reactor is under construction, has been established at Kalpakkam (Tamil Nadu) to carry out research and development in the areas of fast reactor technology and the associated fuel cycle. All the major compunents including reactor assembly, sodium pumps, sodium heat exchanger, steam generator and handling flasks for the test reactor were fabricated by Indian manufacturers. The design, construction and R & D experience generated at this research centre would provide sufficient confidence to undertake the construction of a large fast breeder reactor. Infact the preliminary design of a 500 MWe prototype Fast Breeder Reactor has already been completed. It is envisaged that such reactors may be commissioned in mid 1990s.

New Research Centre

A new centre for advanced technology has been planned at Indore (M.P.). Here necessary infrastructure will be developed for research in thrust areas of high energy accelerators, lasers and fusion using advanced technology such as plasma physics, particle beams, cryogenics, superconductivity. computer modelling, microelectronics etc.

Training of Personnel

Right from inception of the atomic energy programme in the country, emphasis has been laid on the development of scientific and technical personnel so that the country would not have to look abroad for experts. A training school was established in BARC in August 1957. About 150 young graduates in science and engineering are selected every year for a one year integrated course.

BARC also conducts various other training courses to meet specialised requirements such as for hospital radiological physics, radiation medicine, safety aspects in industry, medical research applications of radiation sources including radioisotopes, industrial radiography, research reactor operator and technicians etc.

The Nuclear Training Centre at RAPS, Kota, was set up in 1968 for training, maintenance and operation personnel for nuclear power plants. It trains around 130 graduates at a time in different areas of work. Training includes field training for 18 months at operating power stations.

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International Relations

India is a member of the International Atomic Energy Agency right from its inception in 1957 and designated member on its Board of Governors as one of the most advanced in the technology of atomic energy. India offers training facilities, fellowships, scientific visits etc. to member-countries of the International Atomic Energy Agency under its Technical Assistance Programme. Services of scientists from India for Expert Assignments in various countries under this programme are also being made available. Many experts from India have assisted the International Atomic Energy Agency as Members of various Technical Committees and Advisory Groups. India is one of the founding members of the IAEA Regional Co-operation Agreement for South-East Asian countries and is actively participating in its various programme.

Bilateral cooperation Agreements in the Peaceful Uses of Atomic Energy have been entered into with several developed and developing countries with mutual benefits to both sides.

(Nuclear India, 21, 12(1983) pp. 3-6)

SPACE TECHNOLOGY FOR INDIA

By S. Setty and S. Krishnamurthy

The Indian Programme which made a modest beginning with the establishment of the Thumba Equatorial Rocket Launching Station (TERLS) near Trivandrum in 1962 for conducting sounding rocket experiments in Astronomy and Aeronomy, soon established a national base by setting up the technological infrastructure and capability for indigenous development of launch vehicle and satellite technologies and generating a core of trained manpower.

During the seventies, the efforts were primarily geared towards carrying out research and development in a variety of scientific and engineering disciplines of relevance to launch vehicles and satellites as well as conducting selected large scale experiments in communications and remote sensing involving the use of both indigenously built satellites as well as those procured from foreign space agencies. In addition to the successful launching of seven satellites, some technological but mainly experimental application satellites for carrying out communication and remote sensing experiments and development of a satellite launch vehicle, SLV-3, capable of launching a 40 kg satellite into near-earth orbit constitute major accomplishments of space technology during this decade.

The eighties will primarily aim at transforming the experimental efforts of the seventies into semi-operational operational/systems to provide space services in communication, meteorology and remote sensing and the development of launch vehicles capable of launching 1000 kg remote sensing satellites into sun synchronous orbits.

Rocket technology

From the early sixties a variety of Indian sounding rockets have been developed for the exploration of the upper atmosphere and ionosphere and also to carry out astronomy experiments. These rockets, either single stage or two-stage, are spin-stabilised and can launch payloads from a few kg to 350 kg upto an altitude range of a few tens of km to about 400 km.

The decision to develop a Satellite Launch Vehicle (SLV) was taken in the late sixties. A well defined time-bound project to design, develop and flight test an indigenous launch vehicle for injecting a satellite of about 40 kg into a near earth orbit was initiated in 1973.

SLV-3 had its first successful test flight on July 18, 1980 when it placed a 35 kg Rohini Satellite (RS-1) into an elliptical orbit of 900 km apogee and 300 km perigee at an incilination of 40°. Subsequently, on May 30, 1981, a similar Rohini Satellite was injected into a 180 x 424 km orbit. SLV-3-D-2, the last in this series, successfully launched the RS-D-2 satellite with its landmark sensor payload on April 17, 1983.

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Satellite Technology

Satellite technology has been mastered by building and launching seven satellites, both experimental and technological, in a phased manner in the decade 1972-83. Indian capability has been established in the design and development of spinning satellites as well as three-axis-stabilised satellites for both near-earth orbit and geostationary applications.

The first satellite, Aryabhata, launched by a Soviet carrier rocket in 1975 was essentially a technological satellite which enabled the establishment of core facilities in addition to providing us experience in the design, fabrication, launch and in-orbit management of satellites.

Bhaskara I and Bhaskara II, similarly launched in June 1979 and November 1981, were experimental earth observation satellites for observing the earth's surface in the visible, near infrared and microwave frequencies. The Bhaskaras provided valuable experience in integrated end-to-end systems development and application/utilisation, from the configuration of the spacecraft to reception and processing of the remotely sensed data, generation of user oriented data products and their utilisation.

This approach was also followed in the APPLE (Ariane Passenger Payload Experiment) project aimed at acquiring experience in designing, building, launching, operating and utilising a three-axis-stabilished spacecraft in geostationary orbit. The Indian made APPLE spacecraft was launched by European Space Agency (ESA)'s Ariane Launch Vehicle in June 1981. APPLE enabled the conduct of a variety of digital telecommunications/radio experiments and live TV coverage/demonstrations in India.

The Rohini Satellite, RS-1, launched in July 1980 by SLV-3, provided experience in miniaturisation and high density packaging. The second and third Rohini Satellites additionally carried a solid state imaging system, built around a linear photo diode array, for land mark sensing. These were launched by SLV-3 developmental flights in May 1981 and April 1983.

Space applications

The main efforts in space applications are to use space technology for enhancing communications especially with backward and inaccessible regions of the country and develop an effective nation-wide system for the timely survey and management of natural resources and environmental monitoring. In the last fifteen years, a number of applications experiments have been conducted in communications, remote sensing and meteorology.

Realising the potential of satellite television or mass communication and education, particularly in rural India, ISRO developed expertise in space telecommunications, direct TV broadcasting, and the technology of geostationary communications satellite development and their in-orbit management and utilisation.

Satellite Instructional Television Experiment (SITE) was conducted during 1975-76 using NASA's ATS-6 satellite to gain practical experience in satellite-based TV broadcasting to far-flung areas. Satellite Telecommunication Experiment Project (STEP), conducted with the Franco-German Symphonie satellite in 1977-79, was for gaining experience in domestic telecommunications.

The indigenous three-axis-stabilised communications satellite, APPLE, launched in June 1981, provided continuance of the applications programme initiated under SITE and STEP.

INSAT represents the first operational space system in India for domestic communications and meteorology. After the INSAT-IA failure in 1982, the INSAT-IB, launched in August 1983, is the first operational satellite for domestic communications.

Remote sensing

The Indian remote sensing programme aims to develop technology and skills required to supply remotely sensed data from spacecraft, aircraft and other platforms, to demonstrate the utility of such data for efficient management of natural resources and for environment monitoring. A number of aircraft-based remote sensing surveys have been carried out for land use studies, soil surveys, agricultural monitoring etc.

Further, the data from the US Landsats and meteorological satellites, TIROS-N/NOAA-6, along with aerial survey data have been utilised for geo-morphological mapping, soil survey studies, land use studies, forest inventory and management, flood mapping snow melt forecasts, agricultural inventory and crop yield estimates and water-resources survey and management.

The software and hardware for preparing browse products, precision products, colour composites and computer compatible tapes, other data products, the development of visual interpretation and ground truth collection techniques as well as equipment for this programme have enabled India gain the expertise to establish a national end-to-end satellite-based remote sensing system for resources survey and management and environmental monitoring. A National Natural Resources Management System (NNRMS) is under evolution for nationwide co-ordination of various activties pertaining to remote sensing.

Weather forecasting

Use of satellite imagery for operational weather forecasting began in 1960. Seven Automatic Picture Transmission (APT) Stations in the country provide the India Meteorological Department with low resolution imagery in visible and near IR channels from US and Soviet weather satellites. Data from TIROS-N/NOAA-6 satellites are used for sea-surface temperature, cyclone energetics and other studies. Since 1963, India has been regularly making measurements of the upper atmospheric temperature and winds using sounding rockets launched from TERLS. India also participated in the Monsoon Experiment (MONEX-79) deploying four ships in the Indian ocean, to improve the understanding of factors governing the onset, withdrawal, intensity and spatial/temporal distribution of the monsoon.

With the availability of Very High Resolution Radio-meter (VHRR) data and imagery from INSAT-1B, meteorological observations have improved significantly. Reception of local meteorological data from remote Data Collection Platforms (DCPs) through the data relay transponders on INSAT, on a routine basis, will provide an integrated picture of the entire sub-continental weather and climatic pattern.

Programme for the eighties

A perspective for the Indian Space Programme is obtained from the international situation in space and India's developmental needs.

The USA and USSR are rapidly moving to establish orbiting space stations. The US Space Shuttle Transportation System with reusable orbiters is launching satellites with increasing frequency into near-earth orbit from which they can be propelled to their final orbits. The USSR already has orbiting Salyut Stations with which automated space probes dock periodically; the Soyuz space ships take and bring back crews and supplies from Salyut stations.

Europe has developed the Ariane Launcher with France playing the leading role. Ariane's demonstrated ability to place large satellites for communications and other applications into geo-stationary orbit provides independent launch capability for Europe and meaningful competition to the US Shuttle commercial launches. Japan already possesses the M and N launchers capable of launching scientific satellites in low earth orbits and small satellites into geo-stationary orbit.

Using the rocket systems developed for its ICBMs China has already launched eight satellites and recovered some of them. They have recently placed their own communications satellite in orbit.

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The Geo-Stationary Orbit is rapidly becoming a scare resource. Already crowded with communications, meteorology and other satellites, finding suitable geo-stationary slots has become very difficult for late-comers. The 'first-come-first-served' principle followed for many years for regulating parking in this orbit has favoured the nations who possessed the wherewithal to launch and occupy slots.

Plans for India

In this evolving scenario, the strategy for India is clear. If the objective of using space technology for selected national applications is to be realized and the benefits reaped, the country cannot afford to ignore the realities of international geo-politics in space and must develop in independent self-reliant approach.

There are arguments that all countries cannot possess every technology and the late-comers especially from the developing world must perforce be at the mercy of those that possess the technology or have the money to buy it. Such arguments are well-known and not specific for space technology. They are fallacious for any country however small, leave alone the sub-continent of India with its heritage and resources. In the age of electronics, computers and molecular biology, the key to national development and a peaceful and just international order is not dominance of big powers but to discover ways of vanishing disparities through the concerted use of Science, Technology and Humanism.

The Space tasks for India are clear. It must build its own satellites, launch them and put them to use for communications and remote sensing.

With the completion of the experimental phase, the Indian space programme enters the operational phase in the current decade in the areas of communications and remote sensing. The plans during the current decade envisage strengthening the R & D efforts in space applications, communications, meteorology and geodosy and exploring new areas of applications of national relevance, developing operational remote sensing and communication satellites and improving the technology of SLV-3 to launch heavier payloads for remote sensing applications. The following tasks have been set for the Indian space efforts for the eighties.

Launch vehicles

An advanced version of SLV-3 called ASLV is presently under development. ASLV will enable orbiting 150 kg. class of satellites into near earth orbit. Parallel work has also been initiated to develop PSLV, a vehicle capable of launching 1000 kg.

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class satellites into sun-synchronous polar orbits, primarily for remote sensing missions. The programme calls for R & D in advanced inertial systems, materials and fabrication technology, liquid engine technology, soft-ware systems etc. Eventually, the country will establish capability for geo-synchronous launch.

Remote sensing satellites

A new three-axis-stabilized Indian Remote Sensing Satellite (IRS) series, in polar sun-synchronous orbit, is planned for establishing an operational remote sensing satellite system. The first of the series, IRS-1A, is scheduled for launch in 1985-86 from USSR and will carry solid state cameras capable of providing resolutions of the order of 40 metres in four spectral bands in the wavelengths range of 0.4 to 0.9 microns. The data will be used primarily for applications related to agriculture, hydrology, geology and forestry.

The second satellite of the series, IRS-1B, will carry cameras of higher spatial resolution capability, typically between 10 and 15 metres. The IRS-2 series envisages the use of additional sensors for imaging in thermal IR band. The operationalised communication and meteorological services through foreign procured INSAT spacecraft will have to be eventually replaced by indigenous satellites to provide continuity of service in these areas. Plans are on hand to develop such indigenous spacecraft with high reliability and long life.

Collaborative efforts

Space missions are inherently complex and large scale endeavours involving the integration of many disciplines. Though the missions are unique and often outside the experience of a particular industry or institution, the very nature of the technology requires the expertise and facilities in industries and institutions often stretched to their limits. The Indian space programme, from the beginning realised this aspect and has adopted the policy of collaborative efforts to utilise the expertise and infrastructure in other agencies in areas of relevance to the programme. The development of SLV-3 alone involved the participation of more than 20 major industries, some of them in private sector, and several educational and research establishments.

(Yojana, 28, 23(16-31 December, 1984) pp.23-25)

Industrial Sickness : A National Perspective

By A.L. Roongta

Sickness in industry is a very current expression in our country. Fortunately, it is not fashionable to use this word in other sectors of the economy. We do not hear of sick farms or sick houses or sick roads or vehicles, however under-utilised or badly maintained they are.

It is a measure of our perverted compassion for the 'distress' of the affluent owners of industrial assets left dilapidated at the cost of their creditors and the country. Through economic literature, the press and, above all, in term-lending institutions and the banks, repudiation of liability to creditors invites the presumption of sickness.

In other countries, companies get weak, get merged, sometimes liquidated. Industrial assets change hands, get disposed of, disassembled, reassembled. This is all normal and healthy. Grandparents die and grandchildren are born. Only in our blessed land the indolent and recalcitrant are supposed to be immortal.

Where lies sickness?

What part of our industrial economy is not sick? Jute mills, sugar mills, textile weaving mills and some others, apparently, are all sick. But the textile industry as such is far from sick when lakhs of powerlooms are bursting forth despite industrial bureaucary's frenzied attempts to nip them in the bud. Despite their occasional cries of distress, quite a few of the synthetic spinning units have added spindles during the last one year in Rajasthan alone. If only our laws and government policies had not made it a 'hundred hurdles race', powerlooms would have sprung up not only in Bhiwandi. Ichhalkaranji and Surat, but in hundreds of towns, big and small in the country.

In Pali, Jodhpur and Balotra in Rajasthan, dyeing and printing units, despite the sword of the anti-pollution prosecutions hanging over them, have increased their number in scores and turnover on rock-bottom competitive prices in crores ... last year. The costly, the dishonest, the indolent, the obsolete are dying and, underred by their mortality, new enterpreneurs are entering those very industries!

Rs. 3,178.85 crores blocked!

The total institutional credit locked up in sick units showed a marked increase to Rs.3,178.85 crores at the end of 1982, from Rs.2,389.34 crores at the end of the previous year. Rs.800 crores of subsidy by the tax-payers to promote sickness within a year! Figures for the next 18 months are not available. They are estimated to be about Rs.1500 crores.

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These figures were presented by the Government in Parliament in March '84. Why are they on the defensive about disclosing the names of these eminent sick? The grounds advanced are that banks are given statutory protection from disclosing the quantum or particulars of bad and doubtful debts. Disclosing the names of chronic defaulters to the country and to Parliament will help the sick and the doctors as well!

Banks' credit

Of the total amount of Rs.3,178.85 crores locked up in sick industries up to 1982 end, the banks accounted for Rs.2,577.62 crores and the all-India financial institutions for Rs.601.23 crores. The corresponding figures till the end of 1981 came to Rs.2.025.34 crores and Rs.338.79 crores, respectively.

Out of 275 sick industries in the "assistance" portfolio of all-India financial institutions (IDBI, IFCI, ICICI, IRCI, LIC, GIC and UTI) in December, 1982, those belonging to MRTP houses were 29.

Assets of MRTP	Assets	Turnover	Profit before tax
1. Tatas	2430.83	2883.15	213.66
2. Birla	2004.74	2367.08	113.69
3. JK	620.31	575.43	1.77
4. Mafatlal	598.89	833.31	12.32
5. Reliance Textile	512.34	481.97	26.36
6. A.C.C.	473.07	427.48	40.97
7. Thapar	464.50	632.24	37.48
8. ICI	378.31	489.31	16.40
9. Sarabhai	356.91	515.54	1.24
10. Kirloskar	334.29	445.08	32.59

An ex-Chairman of IDBI, when presented with a proposal to write off the IDBI dues in a Birla-managed company a few years ago going into liquidation, chose to go back to the earlier rule of thumb creditor-debtor relationship. He summoned the seniormost advisor to the Group, presented him the choice that if IDBI's money is to be lost in one company, IDBI would disqualify all other companies in which the eminent group executives figure. The surprised elderly gentleman sought his professional guidance: 'But from where can money be put in the company at this stage and how? To which he naively replied, I do not know. I am only a banker. You are an industrialist. You people never need our guidance to take away any amount of money from flourishing companies. Why this predicament only when you have to bring in money? The Chairman confided to the members of the Board of IDBI that the sick dying unit got the money to clear the IDBI's dues, "from heaven"!

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If only we could go back to the pre-managing agency days! For companies which do not have either money or credit to be able to borrow from the investment market, their credit normally would also be NIL in the corridors of financial institutions.

It is interesting to know what a non-resident investor, Swraj Paul has said: "Big industrialists have invested a total of Rs.140 crores, but they exercise control over capital worth Rs.26,000 crores. On the other hand, the country has already taken loans on questionable terms from the International Monetary Fund, while persons who have benefited from government's industrial credit and subsidies have invested huge sums in foreign lands."

Piloting the recently enacted bill for IRDB, Finance Minister Mr. Pranab Mukherji was himself constrained to admit to the chorus of demand from either side of the House for something drastic about the current epidemic, that falling sick and continuing sick had become something of a vested interest.

COSIDICI members

Fortunately, two-thirds of the total development financing of industry done by IDBI is through the members of COSIDICI. In 1983-84 approximately Rs.1,000 crores were disbursed. One hundred percent repayment in time of this money stands insured through the wonderful federal system of our development financing structure. An Industrial Development Corporation (IDC) or a State Financial Corporation (SFC) may catch cold, may also suffer temporary fever. But the very system forbids it to do die a slow death from cancer or TB. This is the prerogative only of companies watched over by the affluent.

In this Orwellian Year, 1984, the large-scale sick industries have a 'Big Brother' in FICCI or similar organisations, which always put the government in the dock and continue pressing for more succour. One such pleading before the government said on 12 July, 1984: The Economic Times. "....there is no reason why fiscal and credit reliefs should be denied to an industry while it actually falls sick."

Diversion of funds

The causes of sickness have been analysed time and again. Among a plethora of ills cited by the industrialists, "an act like diversion of funds" is seldom brought to the fore, which, in fact, is a major factor causing the 'healthy' to gradually become 'sick'.

In a 1979 study conducted by the Reserve Bank of India (with bank borrowings exceeding Rs. 1 crore), two-third of these

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units were found to have turned sick owing to managerial deficiency and outright mis-management, including 'diversion of funds'. It is ironical that not a single unit was found to have turned sick due to shortage of a major input: credit, particularly for meeting working capital requirements. Perhaps it is too much to expect bankers to recognise 'their own' contribution to 'sickness'.

Besides the all-India institutions (IDBI, IFCI, ICICI, LIC, IRCI), the scheduled commercial banks have a vital interest in rejuvenation of sick units. Of the total amount of institutional credit of Rs. 3,179 crores advanced to sick units as in December, 1982, over four-fifths comprised bank credit.

Causes of Industrial Sickness in Large & Medium Industries (1979)*

Causes	No.	%
(a) Mismanagement/management deficiency (including diversion of funds, in-fighting, lack of marketing etc.)	197	52
(b) Market recession	86	23
(c) Faulty initial planning and other technical drawbacks	52	14
(d) Labour trouble	9	2
(e) Other reasons (power cuts, shortage of raw material etc.)	34	9
Total	378	100

*RBI analysis

Growing Industrial Sickness

As at end of	No. of Sick Unit	Outstanding credit (in Rs. crores)
A. Scheduled Commercial Bank		
December, 1979	22,366	1,622.55
December, 1980	24,550	1,808.66
December, 1981	26,758	2,025.54
December, 1982	28,360	2,577.62
B. Financial Institutions		
December, 1979	202	279.00
December, 1980	205*	325.87
December, 1981	224*	388.79
December, 1982	275$	601.23

* IDBI, IFCI, ICICI
$ IDBI, IFCI, IRCI, LIC, UTI

Static dynamism

Large sectors of our economy have been fossilized and straight-jacketed under feudel arrangement financed by benevolent development financing institutions and banks. They are

regularly subsidized on their deficit financing with the hard-earned money of the tax-payer and the depositors in the bank. Seminars in salubrious surroundings are held in this country, going round and round a static situation, concluding wisely that it must remain STATIC. So long as such seminars can be financed by governments, banks and the creditors, sickness can thrive till eternity.

Today, 50,000 odd industrial units reportedly sick include the eminent conspicuous presence of about 500- those owing Rs.1 crore and above. It is these who ow 90% of the Rs.3,100 crores so far blocked. The small in their totality are sick only to the extent of Rs. 350 crores, which would be less than what the small entrepreneurs would be losing out of their hard-earned money perhaps every year in the fierce competition in which they operate.

If only the SFCs were given a directive by the State Government and IDBI, who jointly own them, that they would like these 50,000 or so closed or nearly closed industries to start functioning in the hands of doctors keen to put in their own entrepreneurial capital to cure them of their illness, the present culture and power of SFCs are result oriented enough to change the national scene within a year.

(Chemical Age of India, 35, 8(August, 1984) pp.517-518)

Universities : The Next Iteration?

Universities are among the slowest changing institutions in society. They are agents of intellectual change but resist reshaping their own institutional boundaries. Witness the difficulties when any attempts to break down disciplinary walls are made, when new administrative shapes are proposed, when old autonomies or empires are threatened. "We haven't done it that way before" is the solemn refuge of the faculty, of department heads, deans, and other leaders. To outsiders, this curious kind of resistance seems absurd in those who work in places devoted to pushing back the boundaries of ignorance, to honing fresh minds, and to demanding skepticism in accepting any prescribed truths. Why should the shape of our universities be so sanctified, so inviolate?

Habit, history, and hubris are some of the reasons. American veneration of European institutions helped set our academic concrete. But events are chipping away at this foundation. The price of an education is requiring new responses from institutional boards, faculties, and administrations. Taxpayers should, and will, demand economies of organization to allow expanded educational scope in America. Recession has caused much agonized reappraisal on U.S. campuses. But some change has been thrust upon us. That may stimulate imaginative shifts in educational approaches.

It is vital that the universities take a serious look at their futures. New directions are opening while universities are merely plying their daily business. Charting a course of institutional development for the next generation of research universities is perhaps the most urgent need facing higher education at this time. Networks of research and instruction in high technology may be one way to begin, with alliances developing through the interaction of faculty and students.

University consortiums, coalitions that provide opportunities for faculty interchange, cooperative purchasing of equipment and books, and some cross-listing of courses signal one change. Consortiums may be the outline of what universities will become in the next century. Intellectually or geographically kindred campuses that are linked by agreements might be able cooperatively to exchange people, courses, and equipment to achieve a matrix organization that would provide wider research and educational opportunities to students and faculties while still preserving separate campus identities and loyalties. Universities in Britain have for years, exchanged examiners so that graduates have been measured by comprehensive standards.

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Universities should lead the way toward a regional response to academic needs, toward a new alliance of campuses that will make possible the strongest base for research and learning. If this happens, there will be a real chance to create world universities, institutional matrices capable of cooperative, even international approaches to technological challenges and to such fundamental problems as war, famine, pestilence, and death.

There are logical congeries of campuses that come to mind- in the Boston-New York corridor, in California, in the upper mid-West, in Texas and the Southwest. Some alumni may fear closer cooperation as a threat to identity. That worry will dissipate as their institutions thrive despite slimmer resources, grow in outreach and impact, and as their degrees are enhanced.

Those of us in America's educational enterprise ought to be flexible enough to achieve this new network of talent and opportunity. Will we?

(Science, 225, 4664 (24 August, 1984)

Scientific and Technological Records of the Government of India - Problems of Information Transfer

By Sai Tirmizi

(Summary)

The STI contained in the current and semicurrent records of the Government of India constitutes a vital information resource. Retrieval from this information resource can be facilitated firstly by devising a suitable content-oriented system of description under a provenance-based scheme of arrangement and secondly by adopting a current records schedule for classified and non-classified records in the stage of currency and a transmission schedule for those which are semi-current. While classified STI could be stored in the special records centre to be set up in the Department of Science and Technology, the unclassified STI could be transferred to the National Institute of Science, Technology and Development Studies, which could serve as a national referral centre for this purpose. It is needless to say that liberalization of access to STI is a keystone of development, especially in the third world countries, where import of STI is expensive and dilatory. Harnessing of local STI is comparatively easy and appropriate in these countries and free and easy access to STI for planners, decision-makers, administrators, scientists and technologists is a vital continuing requirement of the present day research and development activities.

(Journal of Scientific and Industrial Research 43 (May 1984) p.235-37)

Brownian and Quantum Motion

A recent demonstration that a classical problem in brownian motion belies Dirac's relativistic equations of quantum mechanics is a reminder of many things that students should be taught.

By John Maddox

The connection between brownian motion and quantum mechanics should be better known, at least to those brought up in the days before the full implications of Feynman's reformulation of quantum mechanics (in 1948) were fully appreciated, perhaps 15 years ago. That will be people's reaction to the neat argument, now published by B. Gaveau et al. (Phys. Rev. Lett. 53, 419; 1984) which sets out to provide a demonstration that Dirac's relativistic wave equation can be derived from a consideration of a simple classical problem in brownian motion. Others will however note that the authors include Mark Kac, now at the University of Southern California, Los Angeles, who first derived the Schrodinger equation from a brownian motion problem in 1959, as well as T. Jacobson (University of Texas, Austin) and L.S. Schulman (Technion, Haifa), who have more recently made important contributions to similar problems.

The starting point for the argument is simple but evocative. Consider a particle moving in one dimension only at some fixed velocity, and let it suffer reversals of direction at random intervals, themselves distributed statistically according to some suitable law, most simply a Poisson distribution. Practitioners in brownian motion problems will readily write down expressions for the probability density (per unit length and per unit time) that the particle is at some place along the line at a certain time, and moving in one direction or the other. Most simply, there is a different function for each direction. The next step is to relate these probability densities to each other by taking account of the conservation in number of the particles moving along the line. The outcome is set of differential equations which must be satisfied by the two probability densities. (In the sequel, these correspond to the two states of chirality or handedness which alone are accessible to relativistic Dirac particles in one dimension.) What the authors assert (and then prove) is that these equations are in an appropriate sense equivalent to Dirac's equation in one dimension. They then show that the same technique can be extended to the full relativistic problem (with three space dimensions).

The origin of this problem is intriguing, for it seems first to have appeared as an exercise for students in the elegant textbook Quantum Mechanics and Path Integrals, by R.P. Feynman and A.R. Hibbs, published in 1965. There, users of the book are invited to calculate the evolution in time of a

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system consisting of a particle moving with the velocity of light in a single dimension, and suffering random reversals of direction. To Feynman and Hibbs, this would merely have been a test of what students had been told in the first thirty pages of the book. To Kac and company, the challenge has been to demonstrate that the connection between quantum mechanics and brownian motion that applies in non-relativistic mechanics also applies to Dirac's equation. That they succeed will not surprise those already in the know.

For the rest of us, there are several missing elements of which the least excusable is Feynman's use of the concept of the path integral. That, of course, is also familiar from classical mechanics. Since de Maupertuis and the principle of least action in the eighteenth century, it has been understood that the path that will actually be followed, and which is thus that dictated by the laws of motion, will be that for which the action (force multiplied by time) is least. For simple systems, forces can be calculated as a function of time from the function of the system called the Lagrangian, essentially the difference between the kinetic and potential energies. Given initial and final states, and starting and finishing times, it is then possible to calculate (in principle at least) the action for all possible paths and to choose that for which the action is least.

The difference between this and quantum mechanics is that there is no unique path for the evolution of a system but that all possible paths must be counted. As Bohr and his disciples were always telling us, a photon confronted with two slits in a screen cannot be said to use one slit or the other, but both.

Each path is relevant; the only meaningful question to ask about the outcome is not where the particle finishes up, but the probability that it should finish up here or there and, to that it is necessary to add together probability amplitudes (one for each possible path), taking account of plus and minus signs, and of imaginery as well as real parts, before calculating the probability (by squaring the amplitude). The essence of Feynman's quantum mechanics is a powerful prescription for calculating the evolution of the amplitude for each possible path. Inevitably, the outcome is a line integral. Although the integrals are not the same as those appearing in classical mechanics, their relationship is plain to see. In passing, it is worth asking whether quantum mechanics would ever be presented to students in other terms, necessarily less direct, if it were not that so much energy had been invested in teaching them to solve differential equations.

The connection with brownian motion is harder to discern. The formal resemblance with quantum mechanics is simple enough.

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Because the process is statistical, the most one can hope to do is to calculate the probability that a particle starting from one place on the line will finish up at another. Thus, if a particle is to start at one place and finish at another after a specified length of time, there is a large (even infinite) number of paths which it may traverse in doing so. The first to recognize this deeper relationship with Feynman's quantum mechanics - the existence of a multitude of paths - seems to have been K. Ito, working on brownian motion in 1951.

In reality a connection between the quantum mechanics of brownian motion gets even more specific. Put briefly, while the probability amplitudes in the brownian motion problem are all real and positive (and are thus simply additive), those which conspire in the calculation of Feynman's propagation functions are not. The quantum version of the calculations can be turned into the other version simply by replacing i (the square root of minus 1) by minus 1 whenever it occurs. The similarity is even more striking when one sees it demonstrated that a specific path in Feynman's formulism can be boiled down to calculating the chances that a brownian particle makes its way along the same such trajectory by random process.

The implication is simply grasped. The propagation of the probability amplitude along an arbitrarily chosen trajectory is indeed to be likened to brownian motion. One of the quirks of that process, the fact that the average displacement of particle is proportional to the square root of the time elapsed, accounts for some of the computational complexity of Feynman's formulism. Taken together, the whole box of tricks makes it intelligible that there should be a correspondence between the theory of quantum fields and that of phase transitions on a lattice. This is yet another part of the case for changing tack on teaching.

(Nature, 311, (13 September, 1984) p. 101)

A STUDY ON ROTATIONAL BRAIN INJURY

By J.C. Misra and S. Chakravarty

(Abstract)

Of concern in the paper is an investigation on brain injuries which may occur owing to an input angular acceleration of the head. The study is based on the use of an improved mathematical model for the cranium. The eccentricity of the braincase is incorporated through the consideration of a prolate spheroidal shell as the representative of the skull. Also the dissipative mechanical behaviour of the brain material (as per the observations of experimenters) has been accounted for by considering the material contained in the shell as viscoelastic. The problem is formulated in terms of prolate spheroidal coordinates. The singularities of the governing equations of motion (when expressed in the prolate coordinate system) are removed by a suitable transformation of the concerned dependent variable, viz. the one that stands for the angular displacement of a representative point of the system. In the first place the solution of the boundary value problem is sought in the Laplace transform space, by employing a finite difference technique. Use of the alternating-direction-implict method together with Thomas algorithm was made for obtaining the angular acceleration in the transformed space. The Laplace inversion is also carried out with the help of numerical procedures (Gauss quadrature formula is used for this purpose). The results of the parametric study are presented through graphs. The plots illustrate the shear stresses and strains in the brain medium. A meaningful comparison of the computational results with those of previous investigations indicate that the eccentricity of the braincase plays a significant role in causing injury to the brain.

(J. Biomechanics, 17, 7(1984) p. 459-466)

R&D for the Production of essential drugs in India - A Pilot Study

The National Institute of Science, Technology and Development Studies (NISTADS), New Delhi, in collaboration with the Management Development Institute (MDI), New Delhi, has conducted a pilot study on the various aspects of R&D in respect of the following five essential drugs which were chosen for their capability to treat widely prevalent diseases in the country: chloroquine, primaquine (both antimalarial drugs), tetracycline, oxytetracycline (antibiotics), and piperazine (an anthelmintic drugs).

The nature of R&D in the drug industry is largely confined to improvements in the production processes for increasing the yield of end products and import substitution for some raw materials. Some companies are also involved in formulations research. However, there is little effort in the industry to conduct basic research for the development of new drugs.

The reasons for this discouraging trend are the low average profit margins (particularly on essential drugs), non inclusion of R&D costs in price-fixation, fluctuating import policies (both in the case of raw materials and finished products) and short patent lives. Another deterrent factor is the high investment required for such research. Further, the incentives given by the government in terms of taxconcessions are the same whether the companies are involved in basic or marginal research. However, the study brings out one thing very clearly that the companies in the public sector generally spend higher percentage of their sales turnover on R&D as compared to companies in other sectors.

The study also reveals that barring oxytetracycline, these drugs are in shortsupply and are therefore imported to the tune of several crores of rupees every year. This is largely because of lower capacity utilization by most companies. The provision for low mark-ups on the category I essential drugs is forcing many companies to diversify their production into non-essential drugs and other products. Companies in the public sector are, however, producing all the drugs under study.

An interesting finding of the study is that while large quantities of chloroquine are being imported because of shortage in production, another antimalarial drug, namely, amodiaquine (which can be used in place of chloroquine) is being exported in large quantities.

The recommendations of the study are: (1) production and availability of essential drugs should be given national priority and a special cell should be created in the Ministry of Chemicals and Fertilizers to regularly monitor the requirement and production of essential drugs, besides ensuring production and availability of raw materials and intermediates required therein. The cell should also monitor the status of technological competence and requirements of the industry, besides directing appropriate R&D plans for the same; (2) to begin with, task forces could be created with regard to specific drugs (e.g. anti-malarial, anti-tubercular, and anti-leprosy); (3) prices of essential drugs should be reduced by reducing/waiving duties and taxes levied at different stages of production of these drugs: (4) companies in the private sector and multinational companies should be motivated to produce these drugs from a more basic stage, and better linkages should be encouraged with allied chemicals and petrochemicals industry for the same; (5) additional incentives such as inclusion of R&D costs in final prices, higher mark-ups and profit margins, etc. should be allowed to further encourage R&D in the drug industry; and (6) large companies with annual sales turnovers of Rs200 million or more should be encouraged to undertake basic research for development of new drugs by spending 5% of their sales turnover on R&D. Small-and medium-scale companies should contribute 2-3% of their sales turnover towards a common pool, to which state and central governments could give matching grants to create state/regional level R&D centres to help them develop, improve and adapt technologies for production of essential drugs.

(CSIR News, 15 August 1984 pp.112-13)

Advances in Geological Science : 1980 - 1984

By Eugen Seibold

Major Problem Areas

The evolution of and interrelations between the lithosphere, hydrosphere, atmosphere and biosphere have always been our key problems. To solve them, we are trained to assume the validity of physical, chemical, and biological laws with which we try to investigate, understand and explain present and past processes in these "spheres."

However, as in human history, complex and subtle interactions of many factors influence these evolutions. They may be gradual or punctuated, both in organic and inorganic aspects. They may be periodic, cyclic or steadily on-going. They may be born or killed by a sudden and unique event, even a catastrophic one.

Our first task, therefore, is to study the Earth and its relevant processes, both as they exist now and throughout their history. However, geologists should be encouraged to look at future trends as well. We should feel an increasing responsibility for providing advice on how to overcome present and future human needs. Earth scientists by profession are familiar with all regions of our planet. We see the rapid but unequal increase in the world's population, the increasingly unequal distribution of material goods, and we know from personal experience that these and other challenges are global in nature.

We also know that mankind is increasingly looking to science to resolve these questions, and that fewer and fewer people are prepared to accept act of nature as acts of God or of fate. Thus, we are increasingly involved - and possibly even blamed - in matters like natural hazards, the guarantee of long-term supplies of food, energy and raw materials, and statements about the tolerance of nature to man's interference on a local, regional or, as in the case of climate, global scale. How, therefore, have we attempted in the past four years to increase and improve our knowledge in order to meet these challenges?

Modern science needs spectacular breakthroughs as ignition sparks to drive it forward and to obtain support from the public. Some of the scientists approached for the preparation of this paper feel that there have been no recent advances which have influenced nearly all fields of earth sciences, such as discovery of vents on mid-oceanic ridges mentioned in Paris in 1980 by my predecessor, Prof. Rudi Trumpy. Others, however, underline the great successes in planetology and the growing recognition that celestial bodies and processes influence our earth permanently. There have also been exciting results from deep reflection seismics and from drilling into the oceanic crust. Looking backward in earch history, earth scientists have become more and more familiar with catastrophic events.

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Naturally, most of the recent results are based on new or better methods and instruments, in areas such as satellite geodesy, space mapping of earth's gravity field to detect structures of the ocean floor, remote sensing, high PT experiments, and geochemical and isotope analysis down to concentrations of 10^{-9} to 10^{-10}g. Tomography to define three-dimensional crust structures and deep crustal drilling are opening a new field in geology. Some enthusiastic field geologists, however, see a danger in this trend for individualists "interested to go where nothing is known or where something does not look right." However, everyone will agree that we all meet looking at geological maps, the optimum way of presenting geological information.

The Lithosphere

From the Earth's lower crust down to its core, we depend on indirect information, except for some narrow crushed lenses of ophiolites and some xenoliths as messengers from the depth. Therefore, the Earth as a planet continues to be a wide field of dispute "between paradigms and paradoxes" (Anderson, 1984).

New seismic results down to some hundreds of kilometers, and geochemical indications using ratios of Rb/Sr and Sm/Nd, for example, strengthen the idea that there is no primative, undifferentiated terrestrial mantle but that there are heterogeneities, both lateral and vertical on a variety of scales. It remains unclear how these heterogeneties are related to geoid features, to melting and differentiation processes, or to possible convection cells. Similar gaps in our knowledge concerning the properties of the "rigid" lithosphere and the "weaker" asthenosphere feed disputes about the mechanisms that drive plates and, especially, about subduction as a recycling agent to explain continental components in mantle basalts (White and Hofmann, 1982).

Two groups of results should be mentioned from studies of oceanic crust. First, the exciting discovery of ocean ridge vents has stimulated detailed geological, chemical and biological investigations (Rona et al., 1983). We now understand better hydrothermal systems and the formation of polymetallic sulphide deposits, and we have learned, for example, that microorganisms may live in environments with temperatures up to 250°C and pressures of 265 atm. New vent findings have been reported from the East Pacific Rise, the Juan de Fuca ridge and from the Mariana Basin of the Philippine Sea, and anomalous contents of ^{3}He in sea-water may help to detect others (e.g. Hekinian et al., 1983). Ideas about the interactions between sea-water and the oceanic crust have also been refined.

A second significant discovery was the penetration of DSDP Hole 504B of 1,076 m into 6.2 million years old oceanic basement in the Costa Rica rift, where a basaltic dike complex is overlain by effusive pillow basalts with breccias and flows (Nature, Dec. 16, 1982). On the other hand one of the open problems remaining is the nature of the oceanic plateaus that cover more than 10% of the sea floor.

As regards the less dense, buoyant continental crust in which 95% of earth history is stored, deep reflection and refraction seismics and three-dimensional tomography of the continental crust and upper mantle have resulted in a whole series of reflectors, suggesting that the continental crust is markedly tectonically layered. If so, near surface structures may no longer be extrapolated to any significant depths.

There are indications of low-angle trusts, some even crossing the Moho, which have transported thin slices of older rocks over younger ones for hundreds of kilometers, and many extensional features have also been detected. Confirmation of these and other ideas will require deeper continental drilling, as demonstrated by the Kola super-deep drillhole into the continental crust of the NW Soviet Union where no "basaltic" layer was reached in spite of seismic indications (Kozlovsky, 1982). Much more attention will have to be paid now to the role of deep fluids in rocks and to measurements in bore holes used as deep crustal labs.

Many of these exciting results are, of course, only first steps towards understanding earth processes such as involved in the evolution of the mantle and crust. Why, for example, did the break-up of Pangaea occur in the Permian? Was it caused by the insolating effects of a giant supercontinental crust, which forced heat transfers from the deeper mantle to begin convecting? And, why did it break up where it did?

During the past few years, morphological and geophysical mapping from satellites and ships has detected details down to less than 1 m on divergent plate boundaries and fracture zones. First results of satellite measurements of intercontinental distances with an accuracy of a few centimeters give us the hope that plate motions can now be measured directly. However, the origin of the magnetic stripes and reversals that we are now accustomed to use in stratigraphy remains unresolved.

Convergent plate boundaries and subduction zones, which are required if the earth is not expanding, continue to be central topics for discussion. For some earth scientists, they remain an unloved child of an unloved theory, for others the seat of the main engine, driving plate motions. Coesite, the high pressure form of quartz, was discovered as statically grown in metasediments of the continental crust, suggesting that the original sediments were subducted during continent/continent collision to depths of 90 km or more before they were tectonically uplifted again. There is also the concept of accretion of terranes, as discussed around the Pacific, now "la grande mode" in the U.S. Cordillera (e.g. Nur, 1983). Is this really one of the important mechanisms for the growth of continents, as well as one of the compensations for losses by erosion from the continents into the ocean? Is Australia really growing by ploughing into an oceanic plate full of oceanic plateaus, seamounts and island arc systems?

During the last years, we have learned to distinguish between the high-stress mode Chilean-type convergent boundary and the low-stress mode Mariana-type (Uyeda, 1983). The former has a shallow-dipping Benioff zone at a young plate border, strong earthquakes, and andesites with porphyry copper deposits, while the latter has contrasting features, such as massive sulphide deposits. But what happens in front of these downgoing plates?

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And what really takes place within the plates? What causes the intraplate uplift of the Colorado plateau in the U.S.A., or the Rhenish Massif in Western Europe (Fuchs et al., 1983), or generally at the beginning of continental rifting? Intrusions of large basic magma bodies into the lower crust? Mantle diapirs with partial melts? On the other hand, what causes subsidence in continental basins or at passive continental margins? Perhaps the answer will come from basin analysis studies in which features and processes extending from 200 to 1,000 km in size can now be approached quantitatively, including diagenetic changes and hydrocarbon maturation.

The Oceans

Plate tectonic theory was born in the oceans. It was partly proven by the work of "Glomar Challenger" under the DSDP program. This ended in November 1983 after 96 legs and 624 drill sites, having trained and made enthusiastic two generations of scientists around the globe. On going discoveries and evaluation of core material and geophysical data, together with computer modelling approaches, have refined our ideas about the formation and evolution of ocean basins and their sediments. As a result, marine stratigraphy, paleoceanography and paleoclimatology are presently at the forefront of world-wide investigations (e.g. Seibold and Meulenkamp, 1984).

During the Cretaceous, oceanic deep waters were apparently influenced predominantly by low latitude, warm marginal seas and seem to have been periodically anoxic in part. The shifting of continents, among other events, caused high latitude cooling resulting in a complete change in climate and in oceanic deep-water conditions during the Tertiary. This general cooling, however, was not continous, for dramatic breaks have now been recognized as at the boundaries between the Paleocene and the Eocene, the Eocene and the Oligocene, and during the Middle Miocene. Recent work has also established relationships between sea-level variations and deep-sea erosion, leading to substantial sediment hiatuses.

Also significant are some obvious and sudden climatic changes during the Pleistocene, and the increasingly convincing indications of Milankovich cycles preserved in marine sediments up to 800,000 years old and possibly going back to the Tertiary. Variations in the CO_2 content of the atmosphere during glacial and interglacial periods are also important for the discussion of future climatic conditions.

Together with the use of magnetic reversals and the record of oxygen isotopes in calcareous shells, the dating of young marine sediments now seems to be possible with an accuracy of less than 5,000 years - an exciting promise for future work on organic evolution and biogeography (Shackleton, N.J., in Seibold and Meulenkamp, 1984). These advances enable us to draft global scenarios with extremely thin time slices - an extraordinary advance in stratigraphy. But, how do we conquer the last 600 million years as a whole, with an average of only one absolute age marker every 2 million years? And, how can we bridge the gap between this accuracy in marine sediments and the stratigraphic record from continental environments? One possibility seems to be the use of global rare events, now more widely accepted than before.

Rare Global Events

The most spectacular example is certainly the widely discussed impact of a celestial body at the Cretaceous/Tertiary boundary (Silver and Schultz, 1982). The event is marked by an unusual concentration of iridium in both marine and continental sediments. It caused mass extinction in marine planktonic and benthic biota, as well as in terrestrial flora and fauna, and afterwards new life forms replaced the extinguished ones. Another mass extinction is known from the end of the Frasnian (McLaren, 1983). A concentration of Ir (and Ni + Co) was found in metallic spherules around the 1908 Tunguska impact in Central Siberia, and a similar concentration has now also been detected in an Antarctic ice core in an annual layer deposited in 1909 (Ganapathy, 1983).

The 1883 Krakatoa eruption gave a warning for global consequences caused by volcanoes. The detailed and on-going investigations of the El Chichon eruption of April 1982 have also given exciting new insights. The latter eruption ejected fine volcanic material up to the stratosphere and circulated from there around the globe, eventually causing a temperature drop in the Northern Hemisphere of 0.25 to 1°C.

Many variations in sea level could also be grouped under sudden events, but recent studies of Holocene transgression curves demonstrated that they are not synchronous because of different effects of loading by water in different shelf environments.

Early Earth History

These new results are all related to the youngest portion of earth history. However, during the past four years very important progress has also been made in Precambrian stratigraphy. The Upper and Lower Proterozoc can now be subdivided by classical stratigraphic methods using stromatolites and acritarchs. However, much more absolute dating is needed to prove or to disprove different ideas about the tectonic and metallogenic evolution of the Precambrian crust.

As for Precambrian life, its very origin is continously discussed. The importance of life for geological processes is under continous discussion. One topic has been the role of microbial benthic organisms since 3.5 Ga, another the dramatic effects of ongoing photosynthesis, finally leading to an atmosphere with permanent free oxygen some 2 Ga ago (Schopf, 1983. Perhaps, the replication of montmorillonites could become a model for the replication of organic molecules as well. In many respects, therefore, the present is not the key to the very distant past.

Further examples of the interaction between life and geology are now found in studies of soil formation and erosion. These processes are deeply influenced by organisms, as is the diagnesis of organic matter, the driving force of all biogeochemical processes, including the formation and destruction of hydrocarbons. The release of CO_2 into the atmosphere and its removal by incorporation into plant or animal tissues or carbonate shells both on land and in the sea may also be mentioned.

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Naturally, all these examples stress the importance of interdisciplinary approaches, and we might be well advised to follow the advice of the Russian proverb, "Don't look for the hare in the deep forest: he is sitting at its edge."

In this connection I would like to mention one project of the International Geological Correlation Programme, which IUGS runs with Unesco, and which is one example of effective scientific cooperation crossing all kinds of political boundaries. Part of Project 156 on phosphorites has considered the evolution of soft-bodied and enigmatic metazoan Ediacaran fauna living some 670 million years ago to the Cambrian radiation event about 100 million years later, which produced so many different mineralized shelly faunas, including those of calcium phosphate. The evolution seems to be related to a very Late Proterozoic to Early Cambrian Phosphogenic episode, and to a period of enhanced oceanic overturn with many phosphate traps in shallow epicontinental seas flooded by a major sea-level rise (Cook and Shergold, 1984).

Planetology

The last broad field of basic science that has produced specially spectacular, though expensive, results in recent years is planetology. Technical breakthroughs allowed the Soviet Venera 13 and 14 spacecrafts to land on Venus, a planet of Earth-like size, providing much valuable data about regional and local topography down to millimeters, and the chemistry of its atmosphere and rocks (McGill, 1983). Similar breakthroughs involving the Voyager missions (U.S.A.) allowed the study of Saturn's rings and satellites, CH_4 in the stratospheric haze of Titan, and many volcanic features including eruptions on Jovian satellite Io.

Scientifically, the most important results of this work seem to me the rapidly increasing attention geologists pay to planetology and to space-earth relations in general. Examples include the impact event at the Cretaceous/Tertiary boundary, the Tunguska event, and the finding of meteorites in Antarctica that appear to have come straight from the Moon and possibly from Mars (Marvin, 1982).

These investigations are deepening our understanding that the Earth is a unique planet. One with ongoing active plate tectonics, with liquid water and therefore with oceans, with unique climatic conditions, and with life as we know it - altogether, a planet with a very fragile environment, the balance of which we have to protect.

Looking to the Future

We must now direct our efforts towards better hazard predictions. The seismic gap concept as used, for example, in Kamchatka, Italy, and California, has given some promising results but should be expanded in space and time. Precursor studies, including strain measurements and other methods, seem to be much more difficult to use, because earthquakes are individual and often multiple events.

Seismic monitoring, on the other hand, was very successful in predicting the Mount St. Helens eruption in 1980, after about 120 years of dormancy (Lipman and Mullineaux, 1981). Earthquake swarms accompany the present Long Valley magma intrusion near Mammoth Lake, east of Yosemite Park, but no one knows what may happen there and when. Similarly, since 1982 the Phlegraean Field uplift, west of Naples, has been a challenge to geologists - and to its inhabitants'.

Predicting the consequences of man's actions as a geological factor is even more difficult. On a world-wide scale, we consume each year a volume of oil which nature needed some million years to produce. At the rate we are burning fuel and destroying forests, the increasing CO_2 content in the atmosphere may influence our world's climate drastically during the next century. Man-made pollution of groundwater, lakes, rivers and the sea is also increasing as shown by geochemical studies in relevant sediments (e.g. Geophysics Study Committee, 1984). For example, at present, natural fluxes of Fe, Cu, Zn, and Pb into the oceans are only 10% of those due to man's input.

Conclusion

So as to meet better all these global challenges, we should first try to improve relations in basic science, especially between academia on the one hand, and industry and government on the other. The latter hide their so-called "secrets" in inaccessible data banks and files; these need to be unburied and to be evaluated more properly.

A second and widening gap is directly connected with the many new results in research summarized in this report. For most developing countries, needing food and water and trying to develop their mineral and other resources, many of these results may be irrelevant today or even tomorrow. One of the main duties for earth scientists from more industrialized nations should therefore be to cooperate with the young geologists of developing regions in solving the urgent problems of their countries, from classical field mapping to modern exploration methods.

All such progress requires well-trained and motivated geologists, and many of our problems can only be solved by international and inter-generational partnership. The ongoing fundamental task for geologists is to explore Earth history with its long time span and with its few changes to look to the future. This must be done now for the benefit of all of us and the coming generations.

(Episodes, 7, 3 (September,1984) pp.3-7)

Materials in Engineering

By R.S. Nelson

The majority of advanced technological developments depend on the integrity and durability of materials. However materials developments are only worthwhile if the materials are used by the engineer in the design and manufacture of components. As engineering assemblies (e.g. planes, vehicles, chemical and process plant and electronics) become more sophisticated in order to meet the growing requirements of the advancing world, materials are required to provide improved physical, chemical and mechanical properties, e.g. stress, corrosion and strength combined with lighter weight and longer life.

Strong international government-backed programmes in materials development are now well advanced in the USA and Japan. In addition, the CEC has identified the materials - engineering areas as important and is planning to launch new programmes in Basic Technologies and Materials for Transportation Technology. Furthermore, the UK Government, through the Department of Trade and Industry, is supporting advanced materials developments across a broad front. In particular the Minister for Information Technology and Research, Mr Kenneth Baker, has recently set up a Materials Advisory Group (MAG) under the chairmanship of Mr John Collyear. This group is currently assessing requirements for new materials and materials processing and will report to the Minister during the summer. Thus, all these activities worldwide point to the growing realisation that developments in new materials are recognised as an important and growing component of our industrial future and hence the world economy.

The general thrust of the new initiatives is to concentrate on so called 'high technology' materials and their processing technology. Materials developments generally fall into three categories: completely new materials, the modification of existing materials and cheaper or improved processing routes for their manufacture. However, new materials developments must not be made independently of the market place, and the initial research should be based on clear market needs and on an early assessment of costs. Thus new research developments should be evaluated together with the 'end-user' and this generally means both the manufacturing engineers and the marketing and sales departments who ultimately sell the products. In this brief editorial I can only outline some of the more important new developments together with some of their applications.

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The field of ceramics in engineering, in its broadest context, is of outstanding importance because of the industrial and strategic national benefits which would arise from extending mechanical engineering applications - improved efficiency, increased plant lifetime, lower costs. For example it is thought that the cost of developing a new aeroengine based on metals to obtain a 10-15% improvement in fuel economy is of the order of £1 bn, whereas 5% improvement could accure from the substitution of metal turbine blades by ceramic blades, either from higher temperature operation or reduced parasitic cooling loss.

In general the benefits of changing from metal to ceramics arise as follows:

- high temperature applications - high temperature strength and thermal insulation capability allied to good erosion - corrosion properties and light weight;

- low temperature applications - hardness and wear resistance, erosion - corrosion resistance and light weight.

Materials of interest include alumina, zirconia, silicon carbide, silicon nitride, sialons, glass, aluminium titanate, etc, or in coating form we also include zirconates, titanium nitride, titanium carbide and tungsten carbide. The major application areas in the engineering field of manufacturing industries are:

- gas turbine systems (turbine blades, shrouds, bearings);

- reciprocating engine system (in-cylinder insulation, valve train gear, turbocharger);

- general engineering (pump seals, valves, machine tools, extrusion dies, etc).

As an indication of the importance of ceramic materials in such applications the estimates for market growth of engineering ceramics in Japan has been quoted to rise from $200m in 1982 to greater than $2000m in 1990.

Composite materials, e.g. glass reinforced plastic (GRP) and carbon fibre reinforced plastic (CFRP), are already finding an increasing use in manufacturing industry. The traditional advantage of such materials is their light weight combined with strength; however by the use of new manufacturing techniques, such as computer controlled filament winding, it is possible to 'design' materials with anisotropic properties to fulfil specific engineering requirements. In addition, the use of such reinforced plastics also depends on the ability to join them effectively to metallic components. Epoxy-based adhesives are usually employed and in this context sophisticated computerised

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finite-elements stress analysis techniques are being developed in order to define the optimum design of joint for maximum strength.

The application of reinforced plastics is growing rapidly in a broad range of market sectors from aerospace to children's toys but their take-up in engineering products will depend on automation of the manufacturing process technology and a better understanding of properties coupled with the development of design technology.

Materials interact with their surroundings through their surfaces and in many engineering applications the limiting feature of such materials is their surface properties. Furthermore by enhancing surface properties the engineer can use cheaper bulk materials, e.g. chromium plating of mild steel for car bumpers. Many surface treatment and coating processes already exist and new high technology processes which make use of plasma and ion beam are currently under development. The engineer is faced with a plethora of competing processes and it is often not clear which is the most suitable for a particular application. There is, thus, a requirement to validate different coatings and treatments in a number of industrial environments in order to generate a database from which the engineer can select the most appropriate. At the same time new and improved coatings need development in order to optimise engineering design so that the maximum benefits can be obtained by industry.

Metal strip is generally produced from ingots or cast rod by a series of metal reduction processes including hot and cold rolling. Such processes are expensive and in the case of some exotic alloys can be impracticable due to brittle fracture. Direct extraction from the melt offers both materials property advantages and cost advantages. The classical example of direct extraction from the melt is the production of amorphous metal strip by rapid solidification - such alloys are known to exhibit novel hardness and corrosion resistance as well as ideal magnetic properties for transformer laminations. However, significant advantage can also be envisaged for the production of both ferrous and non-ferrous metal strip by melt extraction processes, particularly with regards to savings in production costs for complex alloys.

The above gives only a flavour of the new materials development envisaged for the next decade. It should be emphasised that it is the use of new materials by engineers that is seen as a key feature. Closer working relationships between the materials scientist and the engineer must therefore not only be encouraged but must be an integral part of any development programme.

(Physics Technology 15, 4(1984) pp. 175-176)

Major Materials Facilities Ranked

By Arthur L. Robinson

An unusually tight-lipped committee of the National Research Council has released a report calling for the expenditure of up to $900 million for new and upgraded materials research facilities, including instrumentation, over the next 12 years. One reason for the secretary: the committee headed by Frederick Seitz of Rockefeller University and Dean Eastman of IBM's Yorktown Heights Laboratory listed its recommendations in order of priority; that is, which should be funded first.

The rankings are for "major" facilities, defined in the committee's charge as those costing $5 million or more. The biggest ticket items are new sources for synchrotron radiation and neutron scattering research, whose price tags in the report range from $160 million to $330 million. All told, eight of the nine recommendations deal in one way or another with these two areas of research. The ninth is for a $5-million upgrade of the National Magnet Laboratory, a center for the production and use of ultrahigh magnetic fields at the Massachusetts Institute of Technology.

Presidential science adviser George A. Keyworth, II, asked for the study last fall and requested that findings be ready in time to serve as input for the fiscal 1986 budget preparations. One other function of the materials facilities study is the repair of the various lines of communication that were damaged or ruptured during the NCAM (National Center for Advanced Materials) affair (Science, 21 October 1983, p.308).

To be established at the Lawrence Berkeley Laboratory with a synchrotron radiation source as its centerpiece, NCAM was inserted in the fiscal 1984 budget at Keyworth's insistance with little of the customary peer review. Some in the materials research community were particularly outraged and said so. Congress funded only a reduced CAM (without the National), and the synchrotron light source is in abeyance.

Although Keyworth specifically asked that the major materials facilities committee not wrestle with the highly charged issue of big versus little science, there were a number of advocates of the latter viewpoint in the group. Ideally, the report will therefore be read as a statement of what the materials community will come together and support. "It was a big accomplishment to get them all to walk out of the room together," noted one observer.

Prior to its recommendations, the committee listed two prerequisities to any new facilities: that "they are accompanied by expanded

support of smaller materials research programs, including related instrumentation," and that "resources must be provided to operate existing user facilities productively." The latter proviso has already been violated as congressional action on DOE's fiscal 1985 funding will negatively affect the availability of both synchrotron radiation and neutron scattering beam time.

The committee then divided its attention between "new large facilities" and "new capabilities" at existing facilities. Priorities were established separately in each category, Synchrotron radiation and neutron scattering compete with one another for funding, and the recommendations give the impression that the committee paired off a new facility for one with an upgrade for the other. However, the recommendations do parallel closely those of two recent reports, one on each of the two fields.

For example, among the large new facilities, the highest priority went to a $160-million synchrotron x-ray source based on a 6 billion electron volt (GeV) electron storage ring. Exceptionally bright beams of "hard" (short wavelength) x-rays would be produced by wigglers and undulators, special magnets inserted into the storage ring that bend the electrons into a sinusoidal trajectory and thereby greatly enhance the emission of synchrotron radiation. The committee urged an immediate start on design, so that operations could begin by 1992. The Europeans are close to approving a similar machine (Science, 27 July p.391).

On the new capabilities side of the ledger, the Committee gave its highest ranking to guide halls and new instruments for the existing reactors at Brookhaven National Laboratory and the National Laboratory and the National Bureau of Standards, which have "cold" neutron sources. Cold or very low energy neutrons are especially valuable for certain types of experiments, and the United States woefully trails Europe in their availability. Guide halls use the neutron equivalent of light guides and thereby maximize the sparse neutron flux. Since it will be 12 or more years before a new steady-state source could be ready, upgrades such as this are essential to keeping U.S. neutron researchers within sight of the competition overseas. Cost is $30 million at each laboratory.

Similarly, the second new facilities ranking was given to a $260-million advanced steady-state neutron source, while the second new capabilities priority went to additional insertion devices for existing synchrotron radiation sources at a total cost of $20 million. The neutron source would provide at least five and possibly ten times the neutron flux as the best existing U.S. reactors. In particular, it would cover the entire range from thermal to cold neutrons.

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Continuing the pattern, the committee gave a lower energy (1 to 2 GeV) synchrotron radiation source of the type proposed for NCAM the third priority. The $70-million machine would generate vacuum ultraviolet light and "soft" (long wavelength) x-rays. Meanwhile, an experimental hall and instrumentation for a pulsed neutron source now under development at the Los Alamos National Laboratory, at $15 million, came in third on the new capabilities list.

The pattern broke down for the final selections. The last new facilities recommendation was a $330-million high-intensity pulsed neutron source. Pulsed sources are based on proton accelerators. This one would generate ten times the flux of the Los Alamos source and the go-ahead on the advanced machine would await results from there.

Rounding out the new capabilities, the magnet lab upgrade was fourth. And new targets to increase neutron fluxes from the pulsed sources at Los Alamos and Argonne National Laboratory were fifth on the list.

The committee concluded the entire set of recommendations minus the pulsed neutron source could be financed for $50 million per year over the next decade.

(Science, 225, 4662 (10 August, 1984) p.740)

THE SEARCH FOR A MALARIA VACCINE

The Goal is in sight - a vaccine against malaria looks feasible at last giving researchers a new weapon to eradicate this ancient disease

By Gina Kolata

Parasitology, a long neglected field, is now becoming a hot research area. Investigators who are familiar with the field say it is becoming attractive to others because its problems are approachable with the new methods of molecular biology and because the problems are scientifically interesting as well as medically important. An estimated 3 billion people suffer from parasitic diseases. Reflecting this new interest in parasitology, the MacArthur Foundation recently announced that it is starting a $20-million research program. Science will be reporting on the most recent developments in parasitology in a series of Research News articles, beginning with the following story on malaria.

Research on malaria has been nothing if not humbling. Despite nearly a hundred years of attempts at eradicating the disease, it still threatens 2 billion people, which is nearly one-third of the world's population, afflicts about 300 million people a year and causes 2 million to 4 million deaths. Yet ever since the parasite and its mosquito vector were identified at the end of the last century, researchers have predicted that victory over malaria was just around the corner.

But now, investigators say, they have overcome their naivete about the disease and they truly understand what they are up against. And they have the powerful techniques of molecular biology at their disposal, enabling them to clone genes of the malaria parasite, identify how the parasite interacts with its host, and discover how to foil those interactions. Researchers may not be able to wipe out malaria in the next few decades, but they should be able to develop a vaccine that will make inroads against the disease, especially when combined with drug treatment and insecticides.

Funding agencies agree. The U.S. Agency for International Development (AID) just decided to double its funds for research on a malaria vaccine - from $11.9 million to $22.7 million for the years 1983 to 1985. The National Institute of Allergy and Infectious Diseases (NIAID) is spending $5.4 million on malaria vaccine studies, which is one-fifth of the $27 million earmarked for tropical disease research. The total spent on malaria vaccine research in 1984 from government, international, and philanthropic institutions is $17 million, which is a substantial amount for any area of parasitology - a chronically underfunded discipline.

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The story of malaria research until now has been one of great hopes and dashed expectations. It began just before the turn of the century when researchers discovered that malaria was not caused by bad air (Italian for bad air is mala aria) or decay or filth but by a single celled creature, a protozoan, that is carried by Anopheles mosquitoes. Ronald Ross, who discovered the mosquito vector, thought that malaria could be eradicated from Freetown, Sierra Leone, if people would just sweep up the puddles where the mosquitoes bred. But even today malaria is endemic in Freetown.

By the end of World War II, scientists recognized that the pesticide DDT was extremely effective against the Anopheles mosquito and that the drug chloroquine killed Plasmodium, the malaria parasite. So, in 1957, the World Health Organization (WHO) launched an ambitious and expensive program to use DDT and drugs to rid the world of malaria. At first, the WHO attempt, which cost about $6 billion, seemed effective. By the mid-1960's, malaria was eliminated or nearly gone from 80 percent of the target areas. But then the picture began to change. The mosquitoes began developing resistance to DDT and the protozoa became resistant to the drugs. Malaria came back with a vengeance in many tropical areas. In Sri Lanka, for example, the WHO effort had caused a drop in malaria cases from an estimated 1 million to only 17 by 1963, 5 of which were imported from other countries. Twelve years later, 600,000 cases were reported and the actual number is thought to have been four times higher.

In retrospect, says James Erickson, who directs AID's malaria program, the health scientists were terribly naive. They should have realized, he says, that "the project was doomed from the start. It had too narrow a focus. As scientists, we're all to blame." Louis Miller of NIAID adds that the researchers should have suspected that chloroquine resistance, at least, was going to occur. In the late 1950's, he says, Indian researchers showed that Plasmodium species that infect mice can become resistant to the drug. However, Miller remarks, "everyone thought that was a peculiarity of the mouse model."

Now, with the bitter experience of the unsuccessful WHO effort behind them, some investigators say their greatest fear is that the malaria parasites will become resistant to a vaccine as well, changing its antigens to elude the vaccine-incuded antibodies. But researchers hope to find antigens to vaccinate against that are so crucial to the survival of the parasite that it literally cannot vary them. Even if such a goal is unobtainable, says Miller, it still may take some time for the parasite to develop resistance to the vaccine and during that time new research may lead to other ways to control the disease. "If (the hoped-for vaccine) may be like chloroquine, but that's not bad. It gets us through the next couple of decades. One shouldn't look at these things as though they will be solutions but as contributing towards a solution," Miller remarks.

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A malaria vaccine, when it comes, will be a first. There has never been a vaccine against a parasitic disease. Developing a vaccine against malaria is far more complex than making a vaccine against smallpox or other viruses or bacteria because the malaria parasite is so much large and because it has a complex life cycle that seems particularly evolved to elude its host's immune system.

A malaria infection begins when a person is bitten by a female Anopheles mosquito carrying one of the four Plasmodium species that infect humans. (There are more than 100 Plasmodium species, which infect birds, reptiles, rodents, and non-human primates.) A form of the malaria parasite, called sporozoites, enters the person's blood from the mosquito's saliva and, within half an hour, each sporozoite invades a liver cell where it presumably is safe from the body's defenses. There each sporozoite starts to divide, forming a structure in the liver cell known as a schizont. Each schizont eventually contains thousands of a second form of the parasite called merozoites. The schizonts rupture and spill the merozoites into the person's bloodstream. There, within 20 seconds, they invade red blood cells and multiply again asexually. The red cells burst open and the merozoites quickly take up residence in other red cells and multiply again. This cycle continues until the person dies of anemia, kidney failure or brain damage, or until the disease is brought under control by the person's immune system or by drugs. In the meantime, the rupturing of the blood cells causes the typical malarial symptoms of chills and fever, although the exact reason for this is not known.

A few of the merozoites in the blood cells differentiate into sexual forms, called gametocytes, which are ingested by Anopheles mosquitoes along with the person's blood. The sexual forms break out of the blood cells when they enter the mosquito's stomach. After a series of events, starting with fertilization, thousands of threadlike sporozoites are produced and go from the mosquito's stomach to its salivary glands, ready to enter a new host when the mosquito takes its next blood meal.

Despite this complicated life cycle, immunity to malaria is possible. The disease usually kills young children below the age of 5. Those who survive have developed immunity. "By age 5 or 6 in Africa, people don't die of malaria infections," says Miller. "Sometimes they have a considerable infection and yet they are not sick. And adult in Africa may have a low fever once a year and get better in a day or so." Mothers pass on immunity to their babies with their breast milk; blood from immune persons can protect children against the symptoms of malaria. Yet immune people living in areas where malaria is endemic frequently carry small numbers of malaria parasities in their blood for the rest of their lives, thereby serving as a

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source of the disease. Even though they may not get very sick from malaria, many of those who carry the parasite are by no means well. Their immune systems are generally suppressed, making them more susceptible to other diseases.

Each stage of the Plasmodium life cycle - sporozoite, merozoite, and gametocyte - is antigenically distinct, and researchers are attempting to make vaccines against each of them. They expect that, eventually, people may be given a combination vaccine that will immunize them against all three forms or, at least against the sporozoites and merozoites. But, for now, the work on a sporozoite vaccine is most advanced.

At first, when the WHO eradication program began to fail and researchers began thinking seriously about producing a malaria vaccine, the conventional wisdom was that a sporozoite vaccine could never be effective by itself. The sporozoites are present in the bloodstream for only about half an hour, investigators reasoned, and a mosquito ejects only a small number of them - a few thousand - when it bites. Moreover, if even one sporozoite escapes the attack by the host's immune system, it will go to the liver and proliferate, creating a malaria infection. Thus, it is frequently argued, a sporozoite vaccine would either have to be 100 percent effective or it would have to be combined with a merozoite vaccine anyway.

This assumption, says Victor Nussenzweig of New York University (NYU) Medical Center, is likely to be incorrect. He and Ruth Nussenzweig head a research team that has shown over and over again in animals that a sporozoite vaccine can give complete protection against malaria. Eleven years ago, it was even demonstrated that immunity against sporozoites can protect humans against malaria. In that study, Harry Most and Jerome Vanderberg of NYU and David Clyde and Vincent McCarthy of the University of Maryland irradiated whole mosquitoes, thus attenuating the sporozoites that the mosquitoes carried. For several weeks, they allowed these mosquitoes to bite volunteers in a Maryland prison. Then they let mosquitoes carrying viable sporozoites bite the volunteers. The volunteers were protected, indicating that they had built up complete immunity to the sporozoites. The immunity only lasted 3 to 6 months, however.

Even if a sporozoite vaccine does not give complete protection, it may still be valuable. Victor Nussenzweig argues. "I have strong reservations about the idea that a vaccine is useless if even one parasite escapes," he remarks. A partially effective vaccine should at least diminish the severity of the disease in children who have not developed any immunity to malaria, according to Nussenzweig. "There is indirect evidence that the disease is more severe when the vector is better -

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when the mosquito has more sporozoites in its salivary glands. If we diminish the inoculum (with a partially effective sporozoite vaccine) there should be a profound impact on the disease in children. And if you consider adults who already have some immunity, you may find that if you diminish the inoculum they will not get the disease."

Until recently, however, it was all but impossible to make a sporozoite vaccine. The problem was getting the sporozoites. The only way was to dissect salivary glands from anesthesized mosquitoes - a tedious and time-consuming operation. A technician has to work for hours to get only 10 to 100 million sporozoites. This problem has now been circumvented by investigators using the powerful techniques of molecular biology.

First, the NYU group produced a monoclonal antibody to the surface of the sporozoites of a mouse malaria. This antibody protected the mice against infection by sporozoites and zeroed in on a protein that seems to sheathe the surface of the mouse malaria sporozoite. Then the Nussenzweigs and their colleagues made similar monoclonal antibodies that identified similar proteins on the surfaces of sporozoites from a species of monkey malaria - P. falciparum and P. vivax. When they mixed these antibodies with the sporozoites, the surface of the parasites peeled off like a skin and the parasites were no longer infectious.

The next step was to clone the gene coding for this surface antigen. Last year, G. Nigel Godson and Joan Ellis of NYU cloned the gene for the antigen from monkey malaria sporozoites. This year Vincenzo Enea, Ruth Nuzzenzweig and their colleagues cloned the gene from the human malaria P. falciparum and Miller and Thomas McCutchan of NIAID and their colleagues at Walter Reed Army Institute of Research cloned the gene from a different strain of P. falciparum (Science, 10 August, p.607).

All of these surface proteins studied so far have short repeated sequences of amino acids. About 40 percent of the molecule consists of these repeats, indicating that it might be possible to synthesize just the repeated segment and immunize with it. "If there is any good candidate for a synthetic vaccine, it is this one," Victor Nussenzweig says. In addition, the sporozoite antibody seems effective against different strains of the same species but not against different species of the parasite.

At the same time as work continues on a sporozoite vaccine, investigators are attempting to determine which proteins of the malaria merozoite would be useful targets for a vaccine. The difficulty is that, unlike sporozoites, which have a single coat protein, the merozoites are antigenically so diverse that researchers suspect they may constantly vary the proteins on their surfaces. For example, it was shown in the 1960's that monkeys

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with chronic relapsing malaria infections have antigenically distinct populations of merozoites in their blood with each relapse. "Up until now, there is no defined candidate for a merozoite vaccine," says Miller. "We first have to identify a surface antigen which is not variable and then we must show that antibodies to this antigen prevent parasite development."

But immunity against merozoites is possible - many people living in areas where malaria is endemic do eventually become immune. The problem, though, is that it may take repeated infections over a period of years to become immune to the repertoire of merozoite antigens. If this is so, Miller points out, it may be as difficult to develop a merozoite vaccine as it is to develop one against influenza. Investigators are hoping, though, that the situation is not this bleak. So far, according to Erickson, about 200 antigens have been isolated from merozoites or infected red blood cells and these are being evaluated to see whether any is suitable for use in developing a merozoite vaccine.

Anthony Holder and Robert R. Freeman of Wellcome Research Laboratories in Beckenham, England, for example, have been working for 5 years with a large surface antigen that they identified on the surface of merozoites from a mouse malaria strain. When they immunize mice with this protein, the animals are protected against an infection with injected merozoites. Now Holder and Freeman are attempting to clone the gene for the corresponding antigen on the surface of merozoites from human malaria strains and to determine, among other things, whether the antigen varies during an infection.

Robin Anders and David Kemp of the Walter and Eliza Hall Institute of Medical Research in Melbourne, Australia, are studying the structure of another protein, the S (for soluble) antigen, of merozoites, which differs a great deal from strain. When people become immune to malaria, Anders says, they have antibodies to the S antigen in their blood. Whether or not it may eventually be possible to find a region of the S antigen that is constant and to vaccinate against it, Anders says, "We think the S antigen will tell us how antigenic diversity is generated because it varies so much."

Peter Perlmann, Hedvig Perlmann, Klavs Berzins, and Birgitta Wahlin of the University of Stockholm and the Karolinska Institute are studying still another antigen. This one is on the surface of red blood cells infected with merozoites. Antibodies to this protein prevent merozoites from entering the red blood cells in vitro. Moreover, says Wahlin, people who are immune to malaria have antibodies to this protein in their serum.

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Finally, there are attempts under way to begin developing a vaccine against gametocytes. Such a vaccine would be of no benefit to the infected person, whose disease and symptoms are caused by the asexual red blood cell forms of the parasite, but it would prevent the transmission of the disease. Any gametocyte vaccine, Miller points out, would most likely be combined with a sporozoite or merozoite vaccine so the person would get some benefit from being vaccinated. So far, the gametocyte antigens that have been identified seem quite variable, but the work on this form of the parasite is just beginning.

Erickson argues, however, that a gametocyte vaccine would be unlikely ever to come into general use because it would be extremely difficult to prove to a drug licensing agency such as the FDA that it is efficacious. To show such a vaccine works, it would be necessary to demonstrate that the population of mosquitoes carrying the malaria parasite drops as a result of the vaccine. But, Erickson remarks, the number of parasites in mosquitoes "may wildly fluctuate from time to time and from place to place. You may see 10 percent of the mosquitoes in an area carrying them one year, 90 percent the next, and 2 percent the year after. We haven't the foggiest idea why this happens." So it would be quite a task to prove that the number of parasites dropped because of a vaccine. Because efficacy would be so difficult to demonstrate, the large drug companies have shown little interest in work on a gametocyte vaccine and does not fund gametocyte vaccine research.

If a vaccine against at least the sporozoite and merozoite forms of the malaria parasite is developed - and almost everyone expects field trials of a sporozoite vaccine, at least, to begin within a few years - a final hurdle will be to find a good way of delivering it. It may be quite difficult to vaccinate in areas of Africa and India, for example, if the vaccine must be refrigerated and then injected with a sterile hypodermic needle. But Bernard Moss and Geoffery L. Smith at the NIAID believe that it may be possible to deliver a malaria vaccine in a vaccinia virus - which is the way smallpox vaccine is delivered. This would mean that the vaccine would not have to be refrigerated, would cost only pennies per dose, and would be administered by scatching the skin.

Moss and Smith are using the methods of genetic engineering to introduce new genes into vaccinia viruses and have already put the hepatitis B surface antigen gene, a herpes gene, and influenza genes into vaccinia. These engineered vaccinia viruses protect animals against hepatitis B, herpes, and influenza infections. Now Moss and Smith are working with the

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gene for the sporozoite surface protein that was cloned by the Nussenzweigs and their colleagues. They have put the gene into vaccinia viruses, have demonstrated that the viruses express the protein, and that when they vaccinate rabbits with the altered vaccinia, the rabbits make antibodies to the sporozoite protein.

Now the hope is that a malaria vaccine will give the eradication effort a new chance. No one thinks it will be a panacea - the parasites could very well become resistant to a vaccine just as they became resistant to drugs. But it will be a new weapon which, combined with sanitation, drugs, and insecticides, could give the world what Erickson calls "a DDT-like chance." It may mean that the first big payoff from molecular biology is a fresh opportunity to wipe out an ancient disease.

(Science, 226 (November, 1984) pp. 679-682)

Trends in Blastocyst Research with Relevance to Development of Contraceptives: General Discussion

By M.R.N. Prasad

The Indo-US symposium on Blastocyst Research concluded with a round table discussion on trends in research with particular relevance to the development of contraceptives. A number of events crucial to the initiation and maintenance of implantation were identified and possibilities of developing a contraceptive modality based on interference with these events in implantation were discussed.

There is a great demand from women and national family planning programmes for simple, effective and safe methods of fertility regulation which can be self-administered either post-coitally or for use when menses are delayed by a few days. The availability of such contraceptive technology would limit exposure to fertility regulating agents only to such occasions when coitus takes place or when there is a probability of pregnancy. Moreover, if fertilization had indeed occurred, interruption would take place at the earliest stage of pregnancy thereby reducing the excessive bleeding encountered with later termination of pregnancy. Methods of post-coital contraception used so far have been reserved primarily for emergency situations to protect women from unwanted pregnancy resulting from rape or acts of unprotected coitus or failed barrier methods.

Probabilities that an act of coitus will lead to conception, with reference to the estimated time of ovulation, is highest during the fertile period (9.6+2.6 days). The objective of any form of contraception related to coitus would be to interfere with implantation irrespective of the day when the drug is taken. A drug effective in inhibiting implantation during the most fertile period is likely to be effective in other periods of the menstrual cycle also.

The areas selected for discussion were:

<u>Uterine sensitivity</u>

- What are the factors that regulate uterine sensitivity and maternal recognition of the blastocyst?
- What are the factors involved in the development of uterine refractoriness? Can refractoriness be induced?
- Are there specific uterine and blastocyst proteins involved in implantation?
- Is induction of a short luteal phase a possible approach to modify uterine environment and render it hostile for implantation?

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Blastocyst

- What is the role of estrogens (ovarian or produced by the blastocyst) in implantation? Can this be interfered with by antiestrogens administered systemically? What is the role of catechol estrogens in implantation?

Luteolysis

Research needs

There are a number of gaps in our knowledge of the processes regulating implantation which need to be investigated. Some of these are indicated in the preceeding discussion. Other areas are:

- hanges in the concentration of stercid receptors during the peri- and post-implantation period.

- are there any enzymes secreted by the blastocyst which are unique and crucial to the initiation of implantation?

- whether the functional life of the corpus luteum can be prolonged by hCG administration, if so, for how long? Such a model would be useful in screening luteolytic agents.

- There are at present no biochemical markers for the prediction of implantation. It is necessary to determine if some of the proteins secreted by the preimplantation blastocyst enter the saliva/urine and can be detected by simple tests.hCG has been detected in the preimplanting blastocyst but a diagnostic and sensitive test to determine its presence in saliva/urine as a method to predict implantation remains to be developed.

- develop more potent luteolytic agents. Deglycosylated hCG needs to be evaluated in non-human primates.

- Progesterone receptor blockers: recent reports on the development of a potent progesterone receptor blocker interfering with early pregnancy has evoked considerable interest in these compounds. There is need for the initiation of a programme of synthesis and evaluation of new classes of antiprogestins (steroidal or non-steroidal) based on an understanding of the structure of the progesterone receptor.

Animal models

It is most unlikely that any of the rodent or non-human

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primate species will prove ideal as a model for all aspects of implantation in the human. It may be necessary to carry out some studies in the human after obtaining clearance from the appropriate Ethics Committees of the institutions where such studies are carried out and without compromising safety. Non-human primates are preferred for the reason that they are close to the human but their widespread use depends on a number of factors such as availability, cost, ease of management and captive breeding performance. It is necessary to establish international collaboration between countries/institutions where primate facilities exist to optimize their use in research on regulation of fertility. Likewise, there is need for standardization of methods and models and exchange of scientists and information to achieve the objectives outlined earlier.

Status of research and development with post-coitals and menses inducers

Methods of post-coital contraception used so far include IUD's inserted post-coitally, estrogens used alone or in combination with estrogens. These are reserved primarily for emergency situations to protect women from unwanted pregnancy. Levonorgestrel which has shown satisfactory contraceptive efficacy is being further evaluated clinically. Centchroman, a non-steroidal drug has been evaluated clinically as a once-a-week pill but its future as a fertility regulating agent depends on re-evaluation of its toxicology and determination of a suitable dose to avoid undesirable side effects.

Menstrual regulation could be achieved by a number of approaches: (a) block progesterone receptors and interfere with the preparation of the uterus for implantation, (b) luteolysis leading to decreased progesterone levels and interruption of pregnancy and (c) termination of early pregnancy by prostaglandin analogues. A number of progesterone antagonists have been evaluated clinically. One of these compounds, RU-38486 has received considerable attention recently and is being evaluated clinically for termination of early pregnancy. Preliminary results seem to indicate that the drug, even in high doses, may not result in complete evacuation of the product of conception. A number of prostaglandin analogues are being evaluated clinically for termination of early pregnancy specially under conditions when they are self-administered at home.

It is perhaps reasonable to expect that a post-coital pill or a menstrual regulating agent based on ongoing clinical studies may be available for general use before the end of the decade. However, any method based on new leads which may emerge from basic research studies is unlikely to be available for clinical use in regulation of fertility before research studies is unlikely to be available for clinical use in regulation of fertility before the turn of the century.

(Journal of Bio-Sciences, 6, Supplement 2, (July 1984) pp.121-26)

Can we assess the effects of acupuncture?

By G.T. Lewith

Despite all the recent interest in acupuncture among doctors, scientists, and the public confusion persists about how it works -or indeed if it works at all. Reviews of the technique have tended to concentrate on the mechanism by which it acts as an analgesic rather than its clinical effect on chronic pain. Nevertheless, some 20 controlled clinical studies have attempted to evaluate acupuncture, mainly for painful musculoskeletal conditions. These studies divide into three broad categories: acupuncture compared with conventional treatment, acupuncture compared with random insertion of acupuncture needles, and acupuncture compared with a physical placebo. The results give an overall impression that acupuncture has an analgesic effect in about 60% of patients with chronic pain and that it may be more effective than conventional treatment in some specific conditions such as osteoarthritis of the knee and tennis elbow.

These trials have not, however, convinced the sceptics. Most were poorly designed, with small numbers of patients, muddled entry criteria, short follow up, and no clear definition of success or failure. Further studies will be needed to overcome doubts and provide a sound basis for the selection of patients for treatment. But is it possible to design a scientifically sound clinical trial of acupuncture versus conventional treatment?

The answer is that convincing studies are hard to design- for several reasons - but the task is not impossible provided that the problems are recognised. Firstly, acupuncture usually has a sustained analgesic effect, but one that is unpredictable; some patients find that pain is relieved for only an hour or two while others (receiving exactly the same treatment) report almost complete relief from pain for as long as one or two years. Secondly, the speed of response varies from an immediate improvement in symptoms to a slowly progressive relief of pain. These two features of acupuncture analgesia make crossover trials virtually impossible, and studies need to be designed on a comparative basis.

Next, when acupuncture is compared with conventional treatments some sort of physical placebo will be needed. Several studies have compared acupuncture with random needling, assuming it to have only a placebo effect. Such an assumption is probably incorrect. Any noxious stimulus can attenuate pain elsewhere in the body through the mechanism of diffuse noxious inhibitory control. Probably the best available placebo is mock transcutaneous nerve stimulation, which produces a placebo response of the order of 30% similar to that expected from placebo medication. The machine may be defunctioned simply

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by stopping the transmission of current to the patient while allowing its "black box" to produce audio or visual signals. It may therefore be a more suitable physical placebo than random needling, which has a 40% response rate.

Should a study to compare acupuncture with mock transcutaneous nerve stimulation have different therapists providing the two different treatments? Such a design might, in effect, compare the charisma of the therapists rather than the treatments. If the same therapist provided both treatments he or she might "sell" one particular treatment in a less convincing way than the other. Both options have faults, but it is difficult to devise a valid placebo which may be used consistently, without the therapist's knowledge.

A further problem with most of the published clinical trials is that too few patients have been entered for a [illegible] statistically significant result to emerge. Trial size need not be large, however, if two widely different treatments as acupuncture, with a predicted 60% response rate, versus a physical placebo, with a predicted 30% response rate, are compared. Clear definitions of success or failure of treatment must be made at the start of the study. Pain returns almost invariably after treatment with acupuncture, and it may be more appropriate to use a survival analysis rather than a comparative statistical test.

Another criticism of some of the previous studies is that they have evaluated the effect of acupuncture on pain without analysing the natural history of different types of pain. Ideally a single disease should be studied, and the entry criteria should define a relatively homogeneous group of patients.

Acceptable studies of effects of acupuncture as an analgesic should, then, be single blind, comparative trials, initially using a physical placebo, perhaps later comparing the effects of acupuncture with more conventional treatment. If acupuncture is to become an accepted treatment objective scientific studies must be carried out.

(British Medical Journal, Vol.288(19 May 1984) pp.1475-76)

Childhood Leprosy and Social Response in South India

By Janet M. Berreman

(Abstract)

This paper reports a field study of childhood leprosy in the state of Karnataka, India, as encountered through a private, secular leprosy hospital and its rural outpatient program serving some 60 villages. Symptoms of leprosy among children are subtle, ambiguous and not readily distinguishable from those of relatively innocuous skin ailments with which villagers of the region commonly lump them. In addition, severe stigma attaches to the disease. As a result, diagnosis tends to be resisted, rendering effective treatment difficult.

The research focused on the hospital's comprehensive program of diagnosis, treatment, education and renabilitation, and the responses of people to it. Three categories of response to diagnosis and treatment, as defined by the hospital program, were investigated: regular acceptors, irregular acceptors and Contrary to expectation, those who accept treatment irregularly and hence ineffectively, express greater awareness of the cause, symptoms and treatment of the disease than either those who accept regular treatment or those who refuse treatment. Despite frequent verbal denials of belief in, or fear of, contagion, people's behaviour regarding leprosy and its victims indicates that such beliefs are indeed harbored. The effectiveness of the program is assessed with reference to its policies and procedures as they affect the rural population. Especially effective is the policy of not confronting people with diagnoses of leprosy in problematic childhood cases, but of asserting instead that leprosy can be averted if treatment is accepted. Resistance generated by the fear and stigma of leprosy is thus mitigated by presenting its childhood symptoms as pre-leprous rather than as early leprosy. The research concludes that the program has achieved notable success in each of its aspects and is therefore worthy of emulation elsewhere.

(Social Science & Medicine, 19, 8(1984) pp.853-865)

Nuclear War: Preventable or inevitable? - Conference Report

By Richard Smith

Can 450 doctors from 53 countries meeting and talking for four days do anything to prevent nuclear catastrophe? The delegates to the fourth international meeting of International Physicians for the Prevention of Nuclear War in Helsinki presumably thought that they could, but some of the depressing evidence presented suggested otherwise. One of the copresidents and founders of IPPNW, Dr Bernard Lown, an American cardiologist, pointed out that since the movement started "not a single major weapons system has been dismantled." Indeed, all the evidence suggests that the world is much closer to disaster than ever before. Even in the few days since the conference ended the United States Senate has voted to allow renewed testing of an antisatellite weapon: most delegates, I am sure, would consider this as one more step towards disaster.

One of the working groups at the conference spent two days discussing the question "Is nuclear war inevitable?" "If things go on as now, of course it is," answered one delegate, "but just to answer the question yes is trivial, we must concern ourselves with how and why." And so the group did, considering risk assessment, computer failures, the policies of the superpowers, human error, C³I, (the American military intelligence system) and the like. But was this too rarified? Would all the complex talk and hot air that filled the room for two days lead anywhere? Some of the delegates clearly felt not: they could not make the connection between this fascinating discussion and bringing the world back from the brink of destruction. As one student put it: "We seem to be in danger of becoming an organisation to study nuclear war rather than an enterprise that is trying to stop one."

IPPNW's strengths and weaknesses are intermingled. One strength is that by being apolitical it can attract members from all over the world - and from both East and West. But the weakness of this is that some of its statements have to be so watered down that they become almost meaningless. Furthermore, preventing a nuclear war is essentially a political problem, not a medical or scientific one, and one of the working groups at the conference did break ranks and call for IPPNW to be more political. A second strength of IPPNW is its emphasis on science, but what is needed to prevent nuclear war is not so much scientific information with its endless qualifications (particularly when the experimental material is only two "tiny" bombs exploded 40 years ago) but propaganda. A Swiss woman summed up the problems thus: "The trouble with this conference is that it does not go straight ahead, it goes too deep and gets lost."

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But in the general meeting, several doctors counselled against despair. "In these perilous times, optimism becomes a historic duty," urged the same inspired and inspiring Dr Lown. He reminded his audience that the slogan of the conference was: "Physicians insist: nuclear war can be prevented." Dr Howard Hiatt, the dean of the Harvard School of Public Health, also encouraged the doctors in their work in his keynote address. "The physician's campaign has," he said, "contributed significantly to the social unacceptability of nuclear war fighting rhetoric." Dr Andreas Papandreou, the prime minister of Greece and one of the world's foremost campaigners against nuclear weapons, also managed an optimistic note: "I truly believe that we are now experiencing the awakenings of the peoples of the world on these issues." Doctors, he thought, had played an important part in this awakening.

And the doctors at the conference, despite their depiction in some newspapers, are not communists, deluded radicals, aging hippies, or fringe doctors. They are very much just ordinary doctors. Most of them work with patients everday and they see in their patients the fear of nuclear war. Speaker after speaker emphasised to the audience (most of whom had the grey suits and bald heads that dominate any medical conference) that it was incumbent on every doctor to work to avoid nuclear war.

Nuclear winter

One undoubted aim of doctors campaigning against nuclear weapons is to assemble as much information as possible and present it forcefully to the public. The most important new information to emerge in the past year is that on the nuclear winter, and a whole session was devoted to the topic.

The theory, which emerged less than a year ago, is that a nuclear war would throw up so much dust and smoke into the atmosphere that the sky would be darkened for months and the temperature would drop to as low as - 25°C. This effect might be experienced over much of the globe, leading to tropical forests dying, thousands of species disappearing, and large areas becoming desert. As Dr Lown put it: "Disease and misery would rampage in a cold radioactive world submerged in darkness." Some scientists have even suggested that the effect might be so serve that it could lead to the extinction of the human species.

These ideas have arisen from computer models of the possible effects of nuclear war on the atmosphere, and these models contain so many variables that there is plenty of room for argument over what exactly would happen. Both Dr H Jack Geiger from the USA and Academician V V Aleksandrov from the USSR explained the limitations of computer models. Problems also arise because nobody can be sure of what exactly will happen if nuclear war breaks out: for instance, how many tons of dust

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would be thrown up; how much would be brought down by rain; and would the dust and soot be distributed uniformly or patchily.

Since the original predictions were published in Science others have appeared. A much milder prediction appeared in Nature in March, but Academicians Aleksandrov and a colleague have published other predictions that are worse than those of the Science paper. Because of this confusion, Dr Geiger explained, the National Academy of Science in the USA has been slow to confirm the findings. But, he emphasised, undoubtedly a nuclear winter would occur after a nuclear war. The debate is over how much the temperature would drop, how long the winter would last, how far it would extend, and how many plant and animal species would be affected.

He pleaded with the conference not to become immersed in arguments over technical details. What mattered was that just at a time when any survivors of a nuclear war would have to live off the natural world that world would be at its most hostile. Indeed, to use the word survival in such circumstances was delusory because the world would be so unbearable. Another crucial point was that it had taken 40 years to discover the nuclear winter. How many more appalling effects of nuclear weapons remain to be discovered? He was confident that what we do not know is both far greater and far more awful than what we do know.

One crucial political implication of the nuclear winter is that nowhere would be safe. People in the Third World and in the Antipodes will be affected almost as drastically by nuclear war as those in the north.

The economic effects of nuclear weapons

Another important emphasis of the conference was on the effects on health of spending such large amounts on nuclear weapons. People, and particularly children, are dying now all over the world because of limits on spending on health and education because of high expenditure on nuclear weapons. Dr Hiatt told the conference how in 1982 there was a 46% increase in infant mortality compared with 1981 in five inner city health centres in Boston. That area had had a cut in its maternal and child health grant budget from the federal government from $1.5m in 1980 to $900 000 in 1982. Similar increases in infant mortality have been seen in the poorer areas of Detroit and New York.

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He pointed out, too, that the nuclear powers are a long way down the list of countries with the best infant mortality rates. Finland, Japan, and Sweden, all countries strongly against nuclear proliferation, have the lowest rates of about 7 deaths per 1000. France, in contrast, is 10th with a rate of 10, Britain 13th with 11, the USA 14th with 12, and the USSR 28th with 26. Many of the British doctors at the conference thought that one of the main thrusts of their campaign against nuclear weapons should be to bring home to British patients the link between long waiting lists, unnecessary deaths from renal failure, and the deterioration in the NHS with Britain's high expenditure on nuclear weapons.

Dr Hiatt told the conference of his personal initiative of sending a letter to the leaders of all the nuclear powers asking them if they would independently set aside one modern nuclear weapons system from their budget and spend the money on poor children within their own country. Only Mrs Thatcher had replied, and she had said no.

But the idea that diverting funds from defence to health and education can improve health standards is not just theory: Dr Leonardo Mata from Costa Rica told the conference how his country had abolished its army in 1949 with the result that the infant mortality rate (and other indices of disease) had plummeted despite Costa Rica continuing to be a poor country. In 1965 the infant mortality rate had been 76 per 1000; by 1980 it was 19 per 1000, a lower rate than in most countries in Eastern Europe. Death rates from all infectious diseases are falling. Polio and diphtheria have been eradicated, and in recent years there have been no deaths from measles. Ever since 1959 expenditure on both health and education has been ten times higher than on defence (some defence money is still spent on policemen).

The effects on children of the threat of nuclear war

Children's health may be affected not just because resources are diverted to military expenditure but also because of the anxiety induced with living constantly with the threat of nuclear war. Previous IPPNW conferences have recommended that research into the psychological effects of the threat of nuclear war on children should be one of the main medical thrusts, and this conference had a whole research symposium devoted to the topic. More than a dozen papers were presented, and data were available from more than 10 countries. Sadly, most of these studies have been of poor scientific quality and have consisted of biased observers asking selected groups leading questions. Furthermore, people are often not clear what problem they are trying to answer or what they want to do with their results. Ultimately because no control group is available it will be impossible to prove that children are harmed from the threat of nuclear war, but it should be possible to frame falsifiable hypotheses.

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In the meantime the descriptive studies that have been done have shown that children are very aware of the threat of nuclear war and many say they are anxious about the possibility. Dr Eric Chivian, an American child psychitarist, has studied the problem in American, Russian, and now British children. His groups are not directly comparable and he has spoken to only a few British children, but his strong impression is that children in Britain are not only more frightened than the others about nuclear war but also feel that they have less control over stopping it. But, more optimistically, his and other studies have also suggested that the children of campaigners against nuclear war are less pessimistic than the children of those who do not campaign.

Is accidental nuclear war inevitable?

Much of the anxiety about nuclear war is created by the idea that it may start at any moment through an accident. In the past few years much publicity has been given to accidents with nuclear weapons, and many people think that a false signal from a computer or a drunken soldier pressing the wrong button might be enough to start a nuclear war. The main message that emerged from the working group that discussed this problem was that isolated errors would be most unlikely to be enough to start a war. A much more important problem, said Milton Leitenberg from the Swedish Institute of International Affairs, was the whole way in which the superpowers had been behaving for the past 20 years. Every day all over the globe. American and Soviet forces are nudging each other and playing military games that may one day lead through misunderstanding and poor communication to a full scale war. More important still, Dr Leitenberg argued, is the way that the superpowers are quick to threaten each other with nuclear attack in times of crisis and the coupling of nuclear and conventional forces.

Neither of the nuclear powers in these circumstances would be intending to start a full scale war, and in that sense the war could be called accidental or unintentional, but Dr Leitenberg emphasised, neither of these terms are accurate because the war would be the result of policies that have been in existence for more than 20 years. William Ury from the Harvard Law School nuclear negotiation project drew an analogy with the way that the first world war had started. Most of the major powers had tried to drew back from the war, but their threats and behaviour combined with misunderstanding and poor communication had led inexorably to war. This, Dr Ury thought, is the most likely way for the next war to start. Dr Leitenberg was eventually pushed to put a figure to the relative probability of war starting though the persistent behaviour of the superpowers as opposed to isolated human or computer error: he put the figure at 10 000 to one.

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Both computer experts and psychologists in the group were, however, unhappy with Dr Leitenberg's emphasis. They did not think that one computer error or one drunken soldier pressing the wrong button was very likely to start a nuclear war, but they did think that Dr Leitenberg was understimating the importance of computer malfunctions and human behaviour. The superpower systems for watching the other side and mounting responses are extraordinarily complex, and within such a system their is ample room for human and computer problems to lead to an unintended war. Professor Alan Borning, a computer scientist from Seattle, told the group how the computers used by the American military were primitive compared with those available commercially and much of the programming was also of a low standard. Mistakes were common and were often uncorrected. James Thompson, a psychologists from London, talked about the many psychological problems encountered by people who are part of the military systems. Most important of all might be the behaviour that occurs in times of crisis: often begin to behave in abnormal ways. The commonest comment made after crises by those involved in them is: "I have no idea what overcame us." Everybody in the group was agreed that the chances of "unintended" war were highest in times of crisis.

It followed from these discussions that the only sure way to prevent nuclear war will be to reduce drastically, and ultimately eliminate, the number of nuclear weapons. And before that much desired end is reached the superpowers must also change the way that they posture and play around with these lethal weapons. But the group also heard suggestions on how the risk of unintended nuclear war could be reduced now. These came from William Ury, who has cowritten a best selling book called Getting To Yes. He and the rest of the Harvard nuclear negotiation project have devised a scheme for controlling a nuclear crisis that they have presented to the US government. The two central ideas are that there should be crisis procedures devised and agreed on by the Americans and the Russians and that there should be nuclear crisis control centres staffed round the clock by both American and Russian diplomats and military officers. One would be in Washington and one in Moscow, but they would be connected not only by phone but also by computer and television. The people who staffed these centres would get to know each other, which would allow them to work together with understanding when a crisis came. The working group was impressed with these suggestions, but it was emphasised that they could be no substitute for reduction in nuclear weapons. Dr Thompson quoted in his paper a Turkish proverb: "A weapon is an enemy even to its owner."

Ways forward

Although I may so far have seemed cynical about the conference, I must make it clear that a marvellous buzz of togetherness, optimism, and energy prevailed in Helsinki. Perhaps the main function of the conference is to inspire and revitalise the many doctors working for peace- often in difficult and

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lonely circumstances. And there were plenty of ideas about what those individuals should be doing: the two research symposiums and the 11 working groups generated dozens of recommendations. This again is an example of an intermingled strength and weakness: ideas were abundant but not enough energy was devoted to deciding on priorities. Perhaps, however, it is the job of leaders to decide priorities, and they did suggest some.

Dr Lown thought that the movement should concentrate on working for a test ban treaty. This plan has the great advantage that new technology could make it easily verifiable. Secondly, sophisticated first strike weapons will be impossible to develop if tests are banned - for you cannot rely on a weapon unless you can be sure that it works. Thirdly, he argued, if old weapons could not be rested then confidence in them would be eroded and their numbers would have to be reduced. Dr Lown pointed to the limited test ban agreement of 1963 as a model for this idea. A worldwide public campaign had led President Kennedy to take a unilateral initiative. Premier Kruschev had promptly responded, and a new agreement had been reached in just 13 days. IPPNW's main role in striving for a new test ban treaty will be to change public opinion: Dr Lown concluded, "Our aim above all else should be to mould public opinion to comprehend that nuclear weapons are devoid of any political or military purpose and that they are not weapons but instruments of genocide."

Dr Papandreou also had clear ideas on the way forward. He described the initiatives that his government along with others has been taking. One has been to work for a nuclear free zone in the Balkans, which, importantly, include NATO, Warsaw Pact, and non-aligned countries. Dr Papandreou's hope is that the Balkan zone will link up with a Nordic nuclear free zone, drive a nuclear free corridor through central Europe, and enentually free the whole of Europe of nuclear weapons. Another initiative of his has been to join together with other world leaders - including the leaders of India, Tanzania, Mexico, Argentina, and Sweden - to try to restart negotiations between the superpowers and to push for a freeze. His speech was received with great enthusiasm by the conference.

Finally, the conference heard about practical and immediate steps that IPPNW is taking. Firstly, a letter (which had been through 12 drafts) was sent from the conference to the leaders of the USA and USSR. Secondly, a letter was drafted that any doctor in the world can give to his patients. Thirdly, a report was given on the progress being made in collecting signatures for the international physicians call for an end to the nuclear arms race. More than a million doctors (about a quarter of all those in the world) have now signed the petition. But there

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are big regional variations in the proportions that have signed: for instance, 45% of European doctors have signed but only 0.1% of those from the western Pacific. (Britain has not done well either.) A particular aim is to get at least one signature from all of the 154 countries in the United Nations - so far signatures have come from 83.

These signatures will eventually be presented to the leaders of the five nuclear powers. This is just one part of the work of IPPNW, and many of those at the conference were very optimistic that the leaders of the superpowers would not for long be able to resist the pressure of more than 100 000 members from 53 countries (along with countless others working for peace) to step back from the bring of nuclear catastrophe.

(British Medical Journal, 288, (23 June 1984) pp. 1901-1904)

Nuclear War Warning by Climatologists

By Vladimir Alexandrov

Public consciousness has not yet fully grasped the new paradoxical fact that the geophysical consequences of a nuclear war will be even more disastrous than the direct impact of nuclear weapons.

Topping the list of geophysical effects is a meteorological and climatic aftermath - disastrous qualitative changes of the environment which will begin a few days after the conflict and engulf the entire globe for a period of upto several years, depending on a nuclear war scenario.

The main climatic effect will be an abrupt, exceptionally harsh and protracted cooling off of the air over continents. The fall in temperature will be caused by a heavy contamination of the atmosphere with dust during nuclear bombardment and with the soot given off in fires of cities, industrial complexes, fuel storages and forests.

Temperature Shock

The calculations made with the help of a three-dimensional hydrodynamic model of climate worked out at the computing centre of the USSR Academy of Sciences show that already a month after a conflict with the employment of nuclear charges with a total yield of 10,000 megatons the temperature in the north-west of the USA will be more than 30 degrees Celsius below the usual level. The difference in the northeast of the USA will be over 40 degrees Celsius, in Alaska 35, in Kamchatka 40, in Europe 50, in the Arabian peninsula 51, in Central America 22 degrees Celsius.

The tragedy, however, will not be confined to one hemisphere. A cooling of the air, even in the event of a nuclear war taking place in the Northern Hemisphere only, will also affect the Southern Hemisphere. The fact is that a significant contamination of the atmosphere of the Northern Hemisphere will lead to the rise of a temperature contrast between the hemispheres and to a rearrangement of atmospheric movements on a global scale. And as a result - to the beginning of an intensive transfer of nuclear filth across the equator. In consequence, the air in the Southern Hemisphere and in the tropics will cool down to the same extent as in the Northern Hemisphere.

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But, whereas the temperature in the lower layers of the atmosphere will sharply drop, the contaminated atmosphere as a whole will get heated far more strongly than at present. There will take place a monotonous growth of the air temperature from an abnormally low magnitude at land surface to an abnormally high magnitude at a level of 8-12 kilometres. The atmosphere will become superstable. Vertical covection and, consequently, the vertical transfer of water vapour will be greatly suppressed. As a result, the hydrological cycle of the astmosphere will undergo a drastic change. In the conditions of a heavy unclear contamination, the atmosphere's natural self-purification will proceed much more slowly than at present.

The ocean, because of its colossal thermal inertia, will cool more slowly. Our calculations show that ten months later the average reduction in temperature at the oceanic surface will be about 1.2 degrees Celsius. Therefore the air over the oceanic surface will be cooler by "only" several degrees, which, however, will suffice for the formation of a thick mist that will hang on for several months. Along the coastline, due to the huge temperature contrast between the land and a slowly cooling ocean, fierce hurricanes will arise accompanied by enormous "downpours", but of snow instead of rain, over a large coastal strip. This means that, irrespective of the season of the year, a protracted "nuclear winter" will begin.

In the hinterland of continents rainfalls will be almost zero, agricultural crops will perish and domestic animals, even if they survive the cold, will die of thirst because fresh water for the most part will only be available in a frozen state.

The above-described optical and mechanical effect of the shock fall in temperature of the air over the land surface is the main but not the only climatic effect of a nuclear conflict that we can already predict with sufficient confidence.

Change of the Composition of the Atmosphere

During high-altitude and powerful nuclear explosions in the atmosphere a vast quanity of nitrogen oxides will be released, exceeding by several times their content in a normal state. Those oxides will bind the ozone of the atmosphere. The destruction of the ozone layer will result in that after the dispersal of smoke the intensiveness of perilous ultraviolet radiation coming to the Earth's surface will increase several times over.

Low-altitude nuclear explosions, on the contrary, will provoke an increase in the concentration of ozone, which from a biological point of view is a toxic substance, near the surface of the Earth.

Also most negative will be the effects of the "burning down of civilisation." (About one sixth of the urbanised area of the world - some 240,000 square kilometres - will be fire-destroyed even in a war variant with the employment of nuclear weapons totalling 5,000 megatons.) City fires will emit such poisonous gases as carbon oxide, cyanides, diozine and furans. Their carryover by winds will entail a degeneration of surrounding ecosystems.

The tropical forests, which are the main bearer of organic life on Earth and the chief source of oxygen, will be killed by even a brief impact of cold and darkness because they oxist in a very narrow thermodynamic range and cannot endure sharp fluctuations of temperature and illumination. This will lead to the perishment of the bulk of vegetation and animals, and the biosphere will be left without its main source of oxygen.

The effects I mentioned will arise practically in any nuclear war scenario. Even with an explosion of 100 megatons over large cities the air temperature at the Earth's surface in middle latitudes after a steep fall will remain below the freezing point of water for three months.

The geography of theatres of war is also of no great significance. In the event of a global nuclear conflict its climatic consequences will be evident almost instantly in the Norther Hemisphere, and in the Southern several weeks later. In the event of a local nuclear conflict at any point of our planet the mechanism of overall atmospheric circulation within one to two months will lead to a contamination of the entire atmosphere of the Earth.

All this means that after a nuclear war, whatever its scenario, people surviving the first strike will find themselves confronting a severe cold and the lack of water, food and fuel, exposed to intense radiation, contaminants and disease and under immense psychological stress, and all this will take place in twilight or darkness. Therefore a nuclear war of any dimensions will signify either the disappearance of the human race or its degradation to a level lower than pre-historic.

(The Indian Airman & Spaceman, Vol.38 (9-10), 1984)

Chemicals for Agriculture

By J.R. Plimmer

Agricultural production relies heavily on manmade chemicals used as fertilizers and pesticides, and to regulate plant growth. Pesticides are released intentionally into the environment to control insects, weeds, plant diseases and other pests that affect crop or animal production, as well as to control insects that spread human diseases. Pesticides have a well-established role in agriculture and public health. The benefits of their use in terms of economic returns and of improved human health and well-being have led to the rapid world-wide adoption of this chemical technology. However, their use in advanced countries is often regulated and monitored because of potential problems associated with their injudicious use. Unfortunately, many developing countries lack the experience and expertise necessary to solve such problems.

The quantities of pesticides that do not reach the target organism are of concern because of their potential impact on man and his environment. For that reason, pesticide regulations require submission of data that concern the potential fate of any given pesticide in the environment as well as its toxicity to a variety of non-target species. Pesticide residues on crops or in other foods present special problems; their presence is important not only in human terms, but also in international trade. The term "residues" denotes not only the original pesticide, but also those compounds that may derive from it by metabolism, chemical change, or other processes. Extensive regulations in developed countries deal with the problem of residues, and limits for maximum acceptable quantities of residues in food have been defined. Elsewhere, guidelines developed by the FAO and World Health Organization (WHO) are generally followed.

The WHO has proposed an "acceptable daily intake" of pesticide residues in food, the amount of a pesticide "which during an entire lifetime appears to be without appreciable risk on the basis of all known facts at the time" (WHO Technical Report Series 391, World Health Organization, Geneva, Switzerland, (1968) p.22).

Pesticides may enter man's diet in many ways, but it is not only man that is at risk. There is also considerable concern for the environment. Natural resources such as soil and water must be considered. Non-target species must be protected from the adverse effects of pesticide residues.

It is therefore important to detect pesticides and measure their quantities in food, crops, water, soils, air, animals, fish, and other components of the environment. A range of analytical techniques for detection and quantitative analysis of residues is available. That there may be analytical difficulties, however, becomes apparent when it is realized that in October 1977 the US Environmental Protection Agency listed 1850 substances and more than 40 000 pesticide products. About 1.6 billion pounds (727 000 tonnes) of pesticides were produced in the USA in 1975.

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Analytical procedures capable of detecting low concentrations (0.1 to 0.01 parts per million or even lower) are used. Methods must be selective, and the analyst is often pressed to achieve even greater sensitivity and selectivity as the concern for long-term, low-level effects increases.

For registration of a pesticide, studies of metabolism in plants, birds, fish mammals, and the environment are often required. It is usual for the manufacturer to synthesize isotopically-(C, H or other radioactive atom) labelled molecules for these studies. Incorporation of such markers has become the accepted technique for investigating the fate of complex molecules in biological tissues, soil or other complex matrices. The use of labelled molecules gives unequivocal answers in questions of quantitative or qualitative analyses.

The development of residue data by the manufacturer is necessary to ensure safety for the consumer. However, from the user's standpoint, the manufacturer must also demonstrate that the material is effective, and provide instructions for its use. Rates of application must be prescribed and the recommended methods of use should ensure that harmful residues are not left on the crop.

Pesticide efficacy and safety are thus closely linked. Efficacious use also implies economical use. Pesticides are expensive. Excess pesticide use is not only uneconomical, but may hasten the development of pesticide resistance in insects or weeds, or reduce the number of beneficial organisms.

Safety and efficacy can only be ensured through continuous efforts to monitor and improve the way in which pesticides are used. The programme of the Agrochemicals and Residues Section of the Joint FAO/IAEA Division is concerned with the examination of pesticide residues in a number of commodities, with the way in which pesticides behave in the environment, and with the formulation or delivery of pesticides to the target.

The needs of developing countries

The intensification of agriculture in many developing countries is accompanied by increased imports and use of pesticides. In Venezuela, for example, the annual import of active ingredients increased from just over 4657 tonnes in 1967 to 15 710 tonnes in 1976, and reached 26 600 tonnes in 1982. The Venezuelan experience is typical, as many nations strive for self-sufficiency in food production.

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The majority of pesticides were developed in Europe, North America or Japan. The cost of development of a new pesticide, now about US$ 20 million per compound in the USA, makes it unlikely that new chemicals will become available other than for the world's major crops. Therefore, it will be necessary to rely heavily on currently available compounds. The use of such compounds in tropical agriculture systems is increasing. Because efficacy is potentially affected by climate and other environmental factors, it is essential to develop patterns of use suited to crops, climates, and pests of many different regions of the world. The factors that effect efficacy will also influence residue patterns. Rates of loss of residues will be affected by temperature, rainfall, and sunlight as well as the nature of crops and soils.

Unfortunately, many developing countries have not had sufficient experience of the use of synthetic organic pesticides to be able to solve potential problems associated with their use. Personnel trained to conduct quality control analyses and to monitor crops, soils, and so on for pesticide residues are few, and their facilities are often limited. FAO has recognized this problem, and in 1961 recommended the expansion of its pesticides programme to encompass an effective international approach and to provide governments with appropriate guidance.

Since that time, FAO has become increasingly involved in providing expert advice on pesticide questions, particularly in connection with pesticide registration (including safety activities and control). In addition to these activities, FAO has also sought to provide technical backing for many projects in developing countries that have safer and more efficient use of pesticides as their objective. These programmes include increasing the availability of national personnel trained in various aspects of pesticide use and control and the establishment of laboratory facilities to control the quality of pesticides as well as to measure residues in food and the environment.

A variety of techniques is required to solve pesticide problems. The ability to apply nuclear methods powerfully extends the capabilities of a routine pesticide laboratory. Radioisotopically-labelled molecules are frequently used in analytical studies, in studies of pesticide metabolism, and in investigations of problems of pesticide behaviour in the environment. The Joint FAO/IAEA Division has assisted a number of developing Member States to initiate and conduct pesticide projects that involve the use of nuclear techniques.

The activities of the Agrochemicals and Residues Section are wide-ranging. Projects in Member countries have as their major objectives the improvement of pesticide safety and efficacy, but there are also programmes concerning utilization of agricultural wastes.

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Pesticide residues

Radioisotope-aided studies of pesticides in stored products were among the earlier such studies. The pioneering work of F.P.W. Winteringham and his colleagues in the 1950s demonstrated from the use of halogenated hydrocarbon fumigants, and their effects on wheat flour quality. The use of C-labelled compounds provided a model for many similar studies.

Stored grains, especially in times of plentiful harvests, represent a large investment, but losses caused by pests may be substantial, especially in tropical areas.

Fumigants are used to control heavy infestations of pests, and insecticides may be used to prevent pests becoming established. Residues depend on methods of application, the time interval between application and consumption, conditions of storage, the nature of the stored product, and the nature of the active ingredients. Because radio-isotope techniques are ideal for such studies, the Agrochemicals and Residues Section has established a co-ordinated research programme to study pesticide residues in grain. This aims to measure the type and magnitude of residues, and to demonstrate how terminal residues could be minimized by changes in operating procedures.

The use of pesticides in animal production is routine. Animal feed and the environment may be contaminated with pesticide residues. To study pesticide levels in meat or milk, a co-ordinated programme has brought together a number of studies including several on residues of chlorinated hydrocarbons and organophosphate insecticides, as well as naturally occurring aflatoxins.

Some uses present minor or no problems. In Egypt, for example, residues of methomyl in milk were found to be at such a low level that they were unlikely to be hazardous to the consumer.

The behaviour of pesticides is affected by the environment, and it has been suggested that some pesticides, although not readily degraded in temperate climates, may undergo much more rapid degradation and detoxication in tropical environments. Such considerations are particularly important in developing countries because many of them lie in the world's tropical zones, and many pesticides that can no longer be used in temperate zones may be quite satisfactory under tropical conditions. Their time of residence in the environment or "persistence" may be significantly lower in the latter case. Because many of these pesticides are inexpensive and effective, there seems to be little reason for discarding them if environmental risks are low. Since radiotracers are an ideal tool for measuring rates of degradation and dissipation in tropical (or other) environments, such a study is now being conducted as a co-ordinated research programme.

Bound and conjugated residues

A major breakthrough in techniques of pesticide analysis was made possible by the use of radioisotopically-labelled pesticides. Conventional analysis based on solvent extraction gives quantitative data on the pesticide and its degradation products. It was assumed that the fraction that could not be extracted had been degraded or metabolized and lay beyond scientific concern. Such residues are said to be "bound". However, the issue of their reversibility began to be debated in the 1970's. In this context, "bound" residues appear to be intimately associated with a substrate such as soil, whereas "conjugated" residues are formed by a chemical bonding of a pesticide to a compound of biological origin, such as an amino acid or sugar molecular. The question of their toxicological significance was raised, and regulatory agencies were pressed to take action on this potential problem. To investigate the nature of bound and conjugated residues, sophisticated analytical methodology must be used and the use of radiolabelled pesticides is essential.

Sometimes, "bound" residues constitute a considerable fraction of the total residue, but would escape detection using current analytical procedures. The binding may be due to unusually strong adsorption forces, or to the formation of chemical bonds between the pesticide and components of tissues or soils. The Agrochemicals and Residues Section is conducting a co-ordinated research programme to study some selected bound residue problems in order to determine their nature and quantity and to improve methods for measurement and identification.

Studies with C-labelled pesticides indicated the extent of the problem. For example, 38% of the applied radioactivity remained bound 12 days after malathion was applied to soil. With paraquat, a herbicide, there was no loss of radioactivity from soil after one year in the laboratory, whereas 26% was lost in the field after 15 months. Paraquat represents an extreme case, but a significant percentage of radioactivity remained in a number of cases.

The programme is attempting to improve the methodology and to compare the performance of methods by investigating common chemicals in a number of co-operating nations. The value of specific techniques, such as high temperature distillation, has been demonstrated clearly in comparative studies.

The major issue is that of the toxicological effects of "bound" pesticide residues and their biological availability. The programme provides the essential foundation for the acquisition of quantitative and qualitative data, without which any discussion of the toxicological issues becomes mere speculation.

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Pesticide formulation

The fraction of a pesticide reaching a target organism may be an extremely small fraction of that applied. The active ingredients of a pesticide are formulated to make application easier and to ensure that an effective dose is transferred to the target. The effective dose need usually be only very small, but much of the applied material is dissipated before it reaches the target. A substantial proportion reaches soils or non-target organisms where it represents an "economic" loss and a potential environmental contaminant.

Better formulation improves efficacy and may also improve safety in shipping or handling. Recently, there has been considerable progress in the technology of controlled-release formulations. In these, the pesticide is contained in a reservoir and is released to maintain a predetermined concentration level for a specific period of time. The reservoir serves to protect the active ingredient from loss by volatilization or degradation by environmental forces, and limits its movement from the site of application.

A variety of matrices or controlled-release devices are available; the suitability of a particular technology depends on its effectiveness in a specific situation and on its economics.

Several co-operators in a co-ordinated research programme are evaluating different types of polymer matrix. Radiolabelled pesticides are used for studying the behaviour of the active ingredient, its rate of release and its environmental fate. At the Agricultural Biotechnology Laboratory in Seibersdorf, alginate formulations are being tested because natural polymers appear to offer promise for economical formulation. In Indonesia, for example, natural latex is being used to prepare herbicide formulations and the problem of vulcanization has been solved by irradiation of the latex.

More sophisticated formulation techniques are being examined by co-operators at Neuherberg, in the Federal Republic of Germany, where polymer formulations based on polyethlene or ethylene vinyl acetate copolymers can be moulded or extruded as ropes suitable for aquatic weed control.

A number of formulations have been evaluated in preliminary laboratory studies. Formulations such as that of endosulfan in an alginate matrix will now be tested in the field against cotton insects. Efforts will then continue, through laboratory experiments with radiolabelled materials, to optimize the performance of the new formulations.

Trypanocidal drugs

About 10 million square kilometres of the African continent are infested by the tsetse fly, which transmits trypanosomiasis, a parasitic disease of cattle and humans. This disease reduces livestock production and the suitability of substantial areas for agricultural development.

Control of the tsetse fly and the production of suitable vaccines are approaches to amelioration of the problem. However, neither approach is technically feasible at present and chemotherapy is the only practical solution to the problem of animal trypanosomiasis. It has been estimated that more than 25 million doses of trypanocidal drugs are used annually in Africa. However, no new drugs have been introduced in the last 25 years and there must be heavy reliance on the limited number of drugs available.

Although these drugs continue to be used, experts agree that their mode of action is unknown and that their use could be optimized if the relationship between drug dosage and curative or protective effect were clearly understood.

To obtain the necessary information, radiolabelled drugs are to be used in animal studies at the Kenya Trypanosomiasis Research Institute. Information on the drug level in tissue will be obtained for correlation with biological effects of drug administration. Sensitive methods of analysis for trypanocidal drugs have been developed in the Agricultural Biotechnology Laboratory and will be used in the practical investigation in Kenya.

Utilization of biomass - agricultural wastes

The energy derived from fossil fuel sources is a major factor in agricultural production and distribution. Modern agricultural practices are highly dependent on sources of energy and the increasing cost of energy is a major constraint on agricultural production in both developed and developing countries. Considerable research and development work is now in progress to exploit new sources of energy. In particular, the utilization of renewable resources (manure, crop residues, "energy" crop, and so on) for production of energy, animal or plant nutrients is a field of research in which nuclear techniques can play a valuable role.

Energy as methane or ethanol can be produced from cellulosic wastes by fermentation. Fermentation processes are also widely used for production of food, feed and beverages, and a major endeavour in the expanding field of biotechnology is the extension and improvement of fermentation processes using "tailored" biological catalysts.

A lack of basic understanding of the processes involved limits current techniques for energy production. Generation of methane by fermentation (biogas) is a relatively recent approach to energy production from wastes such as animal manure. Although the scientific background is rudimentary, many constraints have been identified, such as the limited ability of micro-organisms to digest lignocellulosic substrates (wood, straw, and so on). Fermentation may be slowed or prevented by the presence of certain micro-organisms or by the excess of certain intermediates in the breakdown process. Also, fermentation processes occur only within narrow ranges of pH or temperature.

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Energy-production processes and their limitations are therefore being investigated in numerous laboratories throughout the world. Nuclear techniques are being utilized in this research, and the Joint FAO/IAEA Division is supporting a number of research projects. Studies of the processes occurring in methane generators in rural areas and the influence of operating conditions on the efficiency of production of methane are being investigated by the addition of isotopically-labelled substrates to the waste in the fermenting.

It may be possible to enhance the rate of lignocellulose breakdown and the rate of fermentation at lower temperatures by using new strains of micro-organisms. Radiation-induced mutants have been produced in the quest for enhanced capability to degrade agricultural wastes, such as bagasse from sugar-cane production or fruit wastes remaining after fermentation and distillation of spirits.

The observation that African termites can utilize woody materials as a food source suggests that the microfauna present in the gut of termites possess unique capabilities for degrading lignocellulose. A research programme in the Agricultural Biotechnology Laboratory is in progress to isolate, identify and exploit such organisms. Organisms that degrade cellulose have been isolated for mutation studies, and scientists in Nairobi, Kenya, are co-operating with scientist of the Joint FAO/IAEA Division in this project.

(International Atomic Energy Agency Bulletin, 26, 2(June, 1984) pp.13-16)

WHAT IS NUCLEAR POWER?
The Danger of Nuclear Power : Myth and Reality

A fear syndrome concerning nuclear power plants has been inculcaed in large sections of the general public by those who oppose technological progress, industrial modernisation and population growth, or who have some other vested interest in preventing nuclear power development. Wild stories of the possibility of nuclear power plants going off like hydrogen bombs have been assiduously propagated. Myths and half-truths about radiation - "you can't see it, you can't hear it, but it will kill you and your unborn child...." - have been repeated by the ignorant and those who ought to know better alike.

In the following we separate facts from fantasies and outright lies in three areas that are the focal point for fear-mongering. First, radiation and its effects. Second, the nuclear "accident," including the two most prominent catastrophe scenarios - the "sitting bomb" myth, and the "meltdown." Third, we will discuss the issue of nuclear waste.

In the heat of controversy that has surrounded nuclear power, it is imperative that every citizen have the basic scientific facts of the matters within his grasp. To take these issues out of the realm of speculation right from the outset, it is important to take a look at the actual record of nuclear power plant performance in the twenty years or so that commercial nuclear power has been in use. At the present time, with more than 3000 reactor-years of operation, not a single death has been associated with the nuclear power plants around the world. This is a truly phenomenal record when compared with almost any other industry or human activity. The record itself gives the lie to all the scare-mongering not an accident; it is the result of the knowledge, care and competenance that scientists and engineers have applied in developing nuclear technology.

Radiation and Its Effects

It is true that the core of an operating nuclear reactor contains a large amount of radioactivity which, if emitted to the atmosphere, can cause substantial harm to human beings, either plant workers or the surrounding population. It is for this reason that at every stage of a nuclear plant's development - right from the design of the reactor itself, through construction, operation and maintenance - measures are taken and their implementation monitored to prevent such an eventuality. In Nuclear Fact Sheet No. 1 we referred to the intrinsic safety aspects of the reactor design which facilitate control of the nuclear reaction process. Just ahead we will discuss more fully the so-called engineered systems, designed to respond to any conceivable type of accident or emergency that might threaten the integrity of the reactor core and containment. But first, let's look at radiation itself - how is it harmful, how is it dealt with in a nuclear power plant?

The radioactivity contained in a nuclear power plant may take a number of forms, including energetic particles such as beta rays (electrons or positrons) and alpha particles (helium nuclei), or electromagnetic radiation such as gamma rays and x-rays. In passing through human body tissue, radiation deposits energy in that tissue, primarily causing the formation of ion paris. The fundamental measure of a radiation dose is the amount of energy deposited per unit mass of material. The unit normallyused is the rad, which is equal to 100 ergs deposited per gram of tissue.

However, the energy deposited is not itself a measure of the biological damage caused by the radiation. The damage depends upon many factors, including the size and distribution of the dose, the rate at which it is administered, and also the specific type and energy content of the radiation. For small doses and low dose rates, damage-potential is measured by the dose equivalent, which is the dose in rad multiplied by a factor that indicates the relative biological damage due to the radiation being considered. The unit of dose equivalent is rem.

The effects of radiation on humans may be divided into two categories: acute and long term. The passage of radiation through tissue causes damage at the cellular level that, depending on the doze size and dose rate, may show itself almost immediately or after a long latency period.

In recent years especially great pains have been taken by nuclear scientists and engineers to show that any projected radiation levels associated with nuclear technology can be maintained well below the maximum values tolerable to a human being. The guidelines they use distinguish, first, between doses received by a radiation worker - a person knowingly occupationally exposed to identified radiation sources in the course of his normal employment - and a member of the general public. A radiation worker is trained to be aware of the existence of radiation fields, to carry radiation-monitoring devices, and to be subject to stringent operational rules and regulations.

The basic radiation protection standards, prepared on the basis of information obtained from radiologists, x-ray technicians, and others in the field, from cases of biological injury caused by radium, from animal experiments and from other sources, is as follows: that those who are occupationally exposed should receive no more than 5 rems/year in the course of their work; that individual members of the general public should receive no more than 0.5 rems/year, and that large population groups should receive no more than 0.17 rems/year. In every case there are limits on exposures from human-controlled sources (excluding medical practice).

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The standards for those who work with nuclear technology, it should be pointed out, are set about a factor of 10 below exposure levels that have been observed to cause harmful effects. Standards for members of the general public are set another factor of 10 lower than this. This approach, affords a high degree of protection since it is based on an exposure "threshold" that is, where no harmful effects occur below a minimum exposure levels.

The radiation protection guide values given above are for normal occupational exposures. In case of emergency, the limit currently recommended for a planned emergency exposure of occupational workers - other than women in the reproductive age - is 12 rems. An accidental exposure of 25 rems or less to the whole body is believed to have no significant effect on the radiation tolerance of the exposed individual, provided that it occurs only once in a lifetime.

To put this into proper perspective it is necessary to recall something the scare-mongers never tell you: far from being the mysterious inhabitant of a nuclear reactor, radiation is a natural part of our environment. We are all exposed to radiation daily! It is useful to compare the radiation exposure we receive day-to-day from various sources with that from a nuclear power plant.

A chart published by Petr Beckmann of Boulder, Colorado in 1976 showed that a person who lives within 50 miles of a functioning nuclear power plant receives an average of 0.01 millirem (1 rem equals 1000 millirem) of radiation annually. In contrast, the same person receives annually 35 millirems from cosmic rays, 5 millirems from air, 34 millirems from building materials used in building his home, 5 millirems during a six-hour jet flight, 1 millirem from watching colour television, and 50 millirems from one chest x-ray exposure!

Many studies have been conducted to chart the correlation between incidence of sickness and death due to certain diseases and a particular industry or occupation. One study published by G.D. Bell in 1977 on the risk of death from accidents at work for an individual working for 40 years showed that in such hazardous occupations as deep sea fishing, aircraft operation, coal mining, pottery-making, and construction the risk of death exceeds 2 percent. The same study found, by comparison, that the death risk associated with nuclear power plants was as low as 0.3 percent. So far, the allegation of cancer induction from nuclear power plant generated radiation has not been substantiated at all.

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AVERAGE ANNUAL DOSES OF RADIATION
PER PERSON IN MILLIREMS

Nuclear reactor (50-mile radius)	0.01
Natural background	
cosmic rays	35.00
air	5.00
building materials	34.00
food	25.00
ground	11.00
Man-made sources	
coast-to-coast jet flight	5.00
color television	1.00
chest X-ray (one)	50.00

Sources: Petr Beckmann, The Health Hazards of Not Going Nuclear, Boulder Colo: The Golem Press. 1976.

But What If There's An Accident

Under normal reactor operating conditions, as we explained in Nuclear Fact Sheet No. 1, a balance is achieved between production of heat in the fuel and removal of heat by the coolant. Fuel overheating can occur only if the fuel production rate increases enough above normal to exceed the available heat removal capacity, or conversely, if the capacity of the heat removal system decreases below that required by circumstances. This event is referred to as a "loss of coolant accident" (LOCA).

In the case of an increase in the fuel production rate, the availability of systems to shut down the chain reaction rapidly and cooling the deviation from normal operating rapidly and cooling capacity ensures that the deviation from normal operating parameters is not propagated leading to a large scale failure and release of radioactivity. It is only when substantial failures occur in the control or cooling systems that there is a danger of serious release of radioactivity, and, ultimately it is a cooling failure that is to be avoided.

Let me describe the most extreme case of a LOCA. If the coolant supply drops, the temperature of the fuel cladding, or the material that surrounds the fuel, will rise due to the initial heat present in the fuel and because of the additional heat generated by the presence of the element, cesium, which acts to reduce heat removal capacity. If substantial melting of

the fuel cladding occurs, a significant quantity of fuel will be deposited at the nuclear fact sheet page bottom of the reactor, deposited at the bottom of the reactor. It may not stop there, and may reach a temperature so high that it melts its way through the reactor vessel and eventually, within a day or so, through the concrete base of the containment building. With the escape of the fuel from the the noble gases, which together comprise a significant portion of the radioactive inventory, find their way into the atmosphere.

The basic concept of reactor design is to prevent just such a hypothetical accident from happening in the first place. This includes not only the conservative design of these systems and their sitting, but their continuous monitoring and inspection to ensure continued servicibility. In addition, the basic systems are designed with redundancy - or, the deliberate duplication of essential functions to decrease the probability of system failure. As a second layer of protection, back-up systems are available to serve in the event of failure of the basic systems. These include back-up reactivity control systems and several emergency core cooling systems.

Besides the possibility of an internal cooling failure, nuclear power plants are also designed to withstand the impact of external factors and events. The containment building is designed to protect the reactor from tornadoes, broken blades from turbines, airplane crashes and the like. Meanwhile, all internal components are adequately designed to absorb the extra stresses caused by earthquakes. Once the earthquake to be withstood has been determined - based on an exhaustive geological survey of the site area - the plant is engineered to survive the shock.

In this way accidents in nuclear power plants are made unlikely. There is no other industry in which safety considerations play such a decisive role at each step. But like any other industry, there is no definite way to tell whether any accident will occur or not. All one can do is estimate the likelihood of such happening on the basis of a detailed study of the safety features and measures employed, on the one hand, and the probability of various events occurring on the other.

As far as the nuclear industry is concerned, only one such authoritative study has been done. The "Reactor Safety Study", carried out for the U.S. Nuclear Regulatory Commission under the direction of Professor Norman Rasmussen of MIT and published in 1975, still stands today as the most comprehensive effort to calculate the risk from nuclear plant accidents. According to the Rasmussen study, the predicted frequency and severity of nuclear plant accidents with 100 power plants operating is comparable to that from falling meteors.

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What Really Happened at Three Mile Island?

Opponents of nuclear power try to bolster their case by pointing to the incident at the Three Mile Island Nuclear Reactor No. 2(TMI-2) in the state of Pennsylvania in the U.S.A. It is therefore pertinent to look at what actually happened at TMI-2 in March 1979, the most serious "accident" in the history of commercial nuclear power.

The damage to the TMI-2 reactor fuel and the release of radioactivity from the reactor core was caused by a steam safety valve having stuck open for more than two hours. Because the reactor plant operators did not realise that this valve was stuck open during this time, some of the manual protection manuevers the operators took with the cooling water flow failed. As a result, the reactor fuel overheated, cracked open, and some radioactive fission product gases and solids were released into the coolant water. Some of these fission products found their way into the containment building sump (or, drainage) area where they were blown out of the reactor coolant system through the stuck open valve, along with the steam-water mixture. The sump pump in the containment building automatically came on during the first hour, pumping some of the contaminated water into the auxillary building.

Most of the material that was released in the containment building was in gaseous form and consisted of inert gases xenon and krypton, along with some small amounts of iodine gas. The solid material was mostly the elements cesium and strontium. In total, the amount of gas released to the two buildings - auxillary and containment - could easily fit into a regular-size diver's oxygen tank, and the solid material would fit in a half-litre milk bottle.

While no possible explanation has been found as to why the steam valve remained stuck open for two hours and the possibility of deliberate sabotage has been seriously raised - it is nonetheless the case that no one received a large dose of radiation and no death occurred in this accident. In fact, the experience proved that the back-up safety system on TMI-2 worked as designed. Even though some of the features were overridden erroneously by the operators, the safety systems responded by completely protecting the public from significant radiation. The levels of radioactivity released were so low that they posed no threat to public health, even in the long run. The damage was limited to economic damage, that is, clean up, and fuel replacement.

The much publicized story of a possible hydrogen explosion in the reactor vessel followed by a core meltdown was a complete fiction. As the U.S. Nuclear Regulatory Commission admitted, there never was any possibility of such an explosion - the conditions did not exist nor could they since there is no source of oxygen available in the reactor.

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Contrary to the lying claims of the anti-nuclear lobby, the facts of the TMI-2 incident lead to the conclusion that by any standard of comparison, nuclear is still the safest and environmentally cleanest form of energy.

Nuclear Waste: A Political, Not Technical Problem

Nuclear wastes are generally classified as high-level wastes (HLW), transuranic wastes (TRU), low-level wastes (LLW), uranium mine and mill tailings, and gaseous effuents from operating reactors or reprocessing plants. Although all types of waste are important, the most important, and the one causing the major controversy is high-level waste; that is, waste that has a high level of radioactivity. High-level wastes include all the fission products built up in spent fuel over the period of reactor operation, as well as small amounts of some transuranic elements that are left over after the reusable uranium and plutonium have been removed for recycling.

Fission products are almost always unstable (that is, radioactive) isotopes of the fuel elements and must decay for varying periods of time, depending on the element, in order to become stable (that is, nonradioactive). The decay time period can vary from a few minutes to several thousand years or more. These longer-lived fission products make up the bulk of the high-level wastes that have to be disposed of permanently.

The other source of nuclear waste within the fuel includes the radioactive elements created by the non-fission capture of neutrons in uranium or some other heavy element in the fuel. These are generally called the transuranic elements and include neptunium, americium and curium, plus small amounts of uranium and plutonium that do not get separated out during the reprocessing operation. Although very small in amount these transuranic elements are important because they have very long decay times and, therefore, require longterm storage.

Altogether these high-level wastes make up only 4 percent of the entire spent fuel.

The only apparent problems associated with the disposal of nuclear wastes are political, not technical. There are three basic aspects of a nuclear waste management program: reprocessing, or separating the radioactive fission product wastes from the spent fuel, recycling the unused uranium and plutonium fuel included in the spent fuel back into nuclear, reactors, and routing the high-level wastes through a waste storage system. The storage process consists of storing the wastes in concentrated liquid form in holding tanks for a period of about 10 years, solidifying the waste into a very stable glassified form and sealing it into a metal container to be transported to an underground repository - such as the Kolar Gold field shafts, for instance - for a permenent longterm storage.

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The proposed solidification process uses an automated system that converts the liquid waste by evaporation to a fine powder, mixes it with a fine glassy frit material, and converts it to a solid glassy cylinder by heating the mixture to melting and then solidifying it. This is a developed technology which is now used commercially in France.

Once the waste disposal is done properly, nuclear power can be considered as literally pollution free. Compared to coal, nuclear power looks more and more attractive. With coal many kinds of serious environmental effects can be identified which do not occur at all with nuclear power generation. The first is the effect on land use, including the ecological effects of mining operations, the commitment of substantial land area for radiation plant sites, rail delivery facilities, coal storage areas, and the requirements for disposal of solid wastes. Second, there are major effects on air quality stemming from the discharge into the atmosphere of combustion product including nitrogen oxides, sulfur oxides, and particulates. Effects on water quality from the discharge of waste heat and some chemicals, and the effect on land use associated with transmission rights-of-way are essentially common to both generating stations.

(Nuclear Power Fact Sheet No. 2, Fusion Asia)

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